

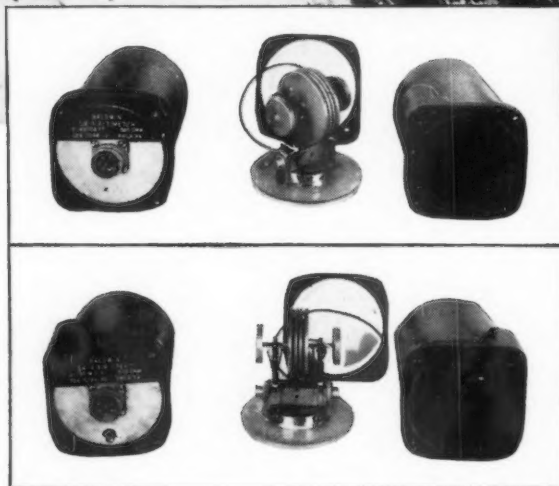
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ASTM BULLETIN

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No. 137

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CABLE ADDRESS—TESTING

Number 137

December 1945

Spring Meeting and Committee Week, Pittsburgh, February 25—March 1, 1946

Statistical Quality Control; Atmospheric Corrosion of Non-Ferrous Metals, to be Covered in Symposiums

THE interesting subject of statistical quality control and its relation to specification requirements will feature one of the sessions of the 1946 Spring Meeting to be held in Pittsburgh during the week beginning February 25 (the October BULLETIN incorrectly gave the week as beginning February 26; this of course should have been February 25), and there will be two other technical sessions comprising a Symposium on Atmospheric Corrosion of Non-Ferrous Metals and Alloys. The latter will afford a long-awaited interpretation of the data and test results from long-time exposure tests which have been carried out by technical Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys.

Cooperating closely with the Pittsburgh District Chairman Thomas Spooner and Secretary P. G. McVetty, both of Westinghouse Electric Corp., are J. J. Bowman, Aluminum Company of America, in connection with the corrosion symposium, and F. T. Mavis, Head, Department of Civil Engineering, Carnegie Institute of Technology, with respect to the session on statistical quality control.

Tentatively it is planned that the corrosion symposium will be held in two sessions, Wednesday afternoon and evening, February 27, and the session on quality control, Tuesday evening, February 26. All meetings, including committee meetings, will be at the Hotel William Penn.

A.S.T.M. Committee Week:

Throughout the week beginning Monday, there will be meetings of a

large number of A.S.T.M. technical committees and subcommittees. An attempt is made to arrange the schedules to result in a minimum of conflicts of the overlapping personnel and at the same time to conserve the time of members. This plan of having a series of committees meet on successive days has worked out very well over the years, although obviously it is impossible to eliminate all conflicts. Nevertheless, the saving in travel time and the expense, etc., is very great and there are other desirable features of so-called Committee Week.

Many of the technical committees have already signified their intention of convening, and early in January there will be distributed to the members an advance schedule of meetings which will be confirmed by notices from the respective committees themselves.

Hotel Reservations:

The Society has obtained from various Pittsburgh hotels through the Convention Bureau assurance of blocks of rooms that should take care of normal sleeping room needs. Members will receive in the near future a return form by which they can make room reservations, but meanwhile anyone who is accustomed to staying at a specific hotel can write directly and make the necessary reservations. Admittedly, the hotel guest room situation is very acute and some of the members may be asked to share twin-bedded rooms with other committee members.

SPRING MEETING SESSIONS

Statistical Quality Control:

In connection with the session on statistical quality control and its relation to specification requirements, it is of interest to note that there is being announced the formation of a new A.S.T.M. Technical Committee E-11 on Quality Control. This will be an expansion and broadening of the present subcommittee on interpretation and presentation of data functioning under Committee E-1, of which H. F. Dodge of Bell Telephone Laboratories, Inc., is chairman. Mr. Dodge is accepting the temporary chairmanship of the new technical committee. Its formation is an indication of the widespread interest in, and application of, statistical methods and practices in quality control. One of the most important publications in this field for many years has been the Manual on Interpretation and Presentation of Data developed by the E-1 subcommittee. During the war period, because of many of the advantages of quality control, there was considerable application in the steel industry and others furnishing ordnance material through both Army and Navy, and there is a strong feeling that there will be continued intensified interest in this field. Consequently, the Pittsburgh District in suggesting the session devoted to the subject, received the full support of the Society's Committee on Papers and Publications. While further details of the session will be announced, the discussion will be

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based on formal contributions by two prominent authorities. Col. Leslie E. Simon, Head, Ballistics Research Laboratory, Aberdeen Proving Ground, one of the leading authorities in the country, will be the main speaker, and Joseph Manuele, Director of Quality Control, Westinghouse Electric Corp., will deliver a second paper supplementing Colonel Simons'. The two authors will closely coordinate their papers. The committee plans for prepared discussion from a number of authorities, and, as usual, there will be provision for discussion from the floor.

Non-Ferrous Metals Corrosion:

Some of the most extensive outdoor corrosion tests of metals carried out in this country have been under the sponsorship of A.S.T.M. Committee B-3. A great many non-ferrous metals and alloys have been on exposure in various programs, some for 15 years, and while most of the important data from these tests have been published in the Society's *Proceedings*, there has been no opportunity to correlate

many of the data or to have authorities close to the work attempt to evaluate the results. Broadly that is the purpose of the six technical papers that comprise the Pittsburgh symposium. This is expected to be one of the most interesting and valuable technical programs sponsored by the Society. The subject is one of vital concern to many thousands of technologists and companies in various industries. There will be more about the scope of the papers in this symposium in the January ASTM BULLETIN.

Pittsburgh¹

PITTSBURGH is called the Historic Gateway to the West, City of Industrial Miracles, City of Culture, Art and Education. It is the center of vast industrial development. Here within a radius of 500 miles is located some 70 per cent of the nation's manufacturing establishments. Excellent railroad, air, highway and water transportation permits fast economical handling of raw materials and finished products. In connection with its commercial facilities, the three navigable

¹ From material furnished by The Convention Bureau.

ivers, Allegheny, Monongahela, and Ohio, carried a combined tonnage in 1940 of 168½ million tons, many times greater than that going through the Panama Canal.

Pittsburgh is the location of six important colleges and universities, including the University of Pittsburgh, Carnegie Institute of Technology, Duquesne University, and Pennsylvania College for Women.

Some of the points of interest include the Block House, which is all that remains of the original Fort Pitt, built in 1764; the Phipps Conservatory, one of the largest buildings under glass in the world, with a constantly changing panorama of floral exhibits, tropical gardens, and outstanding orchid collection; Stephen Collins Foster Memorial, which adjoins the Cathedral of Learning and is the costliest tribute ever erected to a musician; Allegheny Observatory, where Dr. John A. Brashear and Professor Samuel Pierpont Langley made astronomical discoveries of importance; United States Bureau of Mines, one of the best-equipped experimental stations in the country, carrying on extensive experiments in safety in coal mines.

It is no accident that Pittsburgh is frequently termed "the workshop of the world" for here are combined to a unique degree the natural, basic qualities needed for extensive and profitable manufacturing.

Many Technical Features and Exhibit at 1946 Annual Meeting, Buffalo, June 24 to 28, Inclusive

A NUMBER of very interesting technical sessions, including several symposiums, are in prospect for the Society's 49th Annual Meeting to be held at the Hotel Statler in Buffalo during the week of June 24 to 28, 1946. During this week also there will be in progress the Society's 7th Exhibit of Testing Apparatus and Related Equipment, and, of course, there will be upwards of 200 to 300 meetings of the Society's various technical committees. An understatement of this week might be that it will be a busy one for many of our members and technical committee people.

The Western New York-Ontario District Committee headed by B. L. McCarthy, Wickwire Spencer Steel Co., with T. L. Mayer, Buffalo Public Library, Secretary, will be the hosts for the meeting and will be in charge of a number of arrangements.

For example, a photographic exhibit is in prospect which will be organized locally. There is a possibility of a dinner session, plant visitations, and other peacetime meeting features.

To take care of the large number of members and others attending, a Housing Bureau is being established by the Buffalo Convention Bureau, and members will be routed to several of the Buffalo hotels, including the Statler, where all meeting sessions are scheduled.

This is the first time that an Annual Meeting has been held in Buffalo, although the Society held a very successful Spring Meeting and Committee Week there in 1943.

EXHIBIT

The Exhibits of Testing Apparatus and Related Equipment which have been sponsored by the Society at two-year intervals beginning in

1931 have aroused much interest and are considered a valuable adjunct of the annual meeting, focusing attention as they do on the importance of proper instrumentation in the production, testing, and use of new materials, products, and processes. The 1943 Exhibit was canceled because of the war situation and in 1945 the transportation crisis resulted in postponing the Exhibit until 1946.

Many of the leading companies in the laboratory supplies and testing apparatus field will sponsor booth displays and there will be other exhibits of interest in the Society's work.

The Exhibit is to be held on the Statler's 17th floor, which is well equipped for exhibits of this kind. Thus the A.S.T.M. Annual Meeting registration, sessions, most of the technical committee meetings, and the Exhibit will be concentrated.

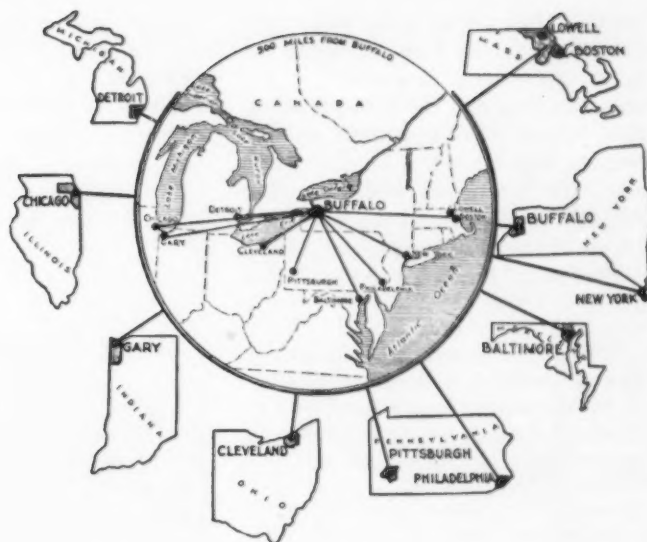
TECHNICAL FEATURES

There never has been any lack of desirable technical subjects to be covered at the Society's meetings. In fact, the reverse is true. It is a problem to provide sufficient time for presentation of the papers together with the oral and written discussions which make these sessions and the consequent publications so interesting and valuable. In almost every annual meeting program one will find symposiums or special sessions sponsored by technical committees, and in Buffalo there will be a session on Industrial Waters under the auspices of Committee D-19, another dealing with discharge phenomena and excitation in the field of spectrographic analysis (Committee E-2), and a third covering Testing of Parts and Assemblies or simulated service testing, which is being organized under the administrative committee on this subject. Other sessions in which committees will have a part will include Symposiums on Fatigue and on pH Measurement, and there is an interesting series of papers to cover Atmospheric Corrosion Resistance of Stainless Steels. Those in the field of concrete will be interested in a projected discussion on durability of concrete, particularly involving freezing and thawing procedures.

Mention should be made of the Marburg Lecture on Protective Organic Coatings as Engineering Materials to be delivered by Dr. J. J. Mattiello of the Hilo Varnish Corp. who is an outstanding authority in this field.

Final announcement concerning the program will be made later since there are always a number of details to be coordinated, but one thing is most definite, namely, that there will be a well-rounded technical program as it is set up by the Committee on Papers and Publications.

As has been the normal practice, many of the papers and numerous committee reports will be preprinted and distributed in advance. (Members should keep in mind also that under the new publication policy there is throughout the year a distribution of papers and other material and not all of the material is concentrated prior to the Annual Meeting.) Details are given in current ASTM BULLETINS.



Interesting Facts About Buffalo

ACCORDING to the September 24 issue of "Buffalo This Week" which is the official guide of the City of Buffalo, October 26, 1825, is probably the most significant date in the city's 161-year history, because on that date the Erie Canal was opened, linking the Atlantic Ocean with Lake Erie. In his article Scott Hayden points out that this canal reduced the cost of transportation from the Hudson River to Buffalo from \$100 to \$10 a ton and the city grew rapidly. An interesting feature of the day was the so-called "gun telegraph" which embodied a series of

cannons firing between Buffalo and New York beginning when the first boat slipped its moorings on the way to New York. It took one hour and twenty minutes for this "telegram" to get to New York. It is reported that with Governor Clinton and his party on the ten-day party were two "elegant kegs" carrying water from Lake Erie which was poured into the ocean at New York, and on the return voyage there was another ornamental keg of ocean water. Now Buffalo has grown from a city of 10,000 when it was chartered in 1832, to be the fourteenth in size in the United States.

1945 Dudley Medal Awarded to W. M. Findley

ONE of the interesting ceremonies at the Chicago District Meeting on October 24 was the presentation of the 1945 Charles B. Dudley Medal to William M. Findley, Assistant Professor of Theoretical and Applied Mechanics, University of Illinois. J. H. Foote, Supervising Engineer, Commonwealth and Southern Corp., who as the Chairman of the Dudley Medal Committee, with Messrs. R. W. Orr and R. B. Young, made an extensive study of the numerous papers eligible, presented Professor Findley to President J. R. Townsend who presented the Medal.

It was not possible to make the presentation as would normally have been done at the Annual Meeting which this year was a business session in New York and advantage was taken of Professor Findley's location at Urbana to have the presentation at the Chicago meeting. Mr. Foote made a special trip

from Battle Creek for the event, returning late at night by motor, and the following evening was at the Detroit District Meeting.

In presenting the medalist, Mr. Foote explained the purpose of the award was to recognize the paper of outstanding merit constituting an original contribution on research and materials. He mentioned that the Medal was named to honor the Society's first President, Charles B. Dudley, and that its chief purpose is to stimulate research and to encourage the presentation of the results of investigations so that our knowledge of materials can be extended. Of the 90 papers examined, he indicated the committee was unanimous in its choice. The winning paper, Creep Characteristics of Plastics, was part of a symposium presented at the Philadelphia District Meeting in February, 1944, this symposium having been developed by the Philadelphia Dis-

trict. After giving some biographical data on Professor Findley, a most interesting fact was pointed out that this was the first presentation where the President of the Society was himself a Dudley Medalist, Mr. Townsend being co-author with W. A. Straw and the late C. H. Davis of the winning paper in 1930.

Professor Findley's response follows:

"Thank you, President Townsend. I wish to express my gratitude for the award of this Medal honoring our first President, Charles B. Dudley, and also to express my appreciation of the stimulating interest of Committee D-20 on Plastics. I am happy to represent the plastics group on the list of Dudley medalists.

"I likewise wish to thank the many investigators whose work has contributed to the present paper, and to my colleagues in the Department of Theoretical and Applied Mechanics and the Engineering Experiment Station of the University of Illinois, and particularly Messrs. W. J. Worley and W. I. Mitchell for aid in the preparation of this paper."

The medalist received his A.B. degree from Illinois College in 1936, majoring in chemistry and physics. He later received his B.S.E. in mathematics and mechanical engineering from the University of Michigan and his M.S. degree in engineering from Cornell in 1939. He has been active in the work of a number of societies including, in addition to A.S.T.M., the A.S.M.E., S.P.E.E., and the Society for Experimental Stress Analysis. Following teaching work at Michigan and George Washington University, he became a member of the faculty



W. M. Findley.

of the University of Illinois where he has been since 1939. Professor Findley has taken an active part in the work of Committee D-20 on Plastics, is chairman of the Section on Repeated Impact and Fatigue. He is the author of a number of technical papers in engineering soci-

ety publications and technical journals.

The Chicago District was pleased to have present at the presentation, Professor Findley's mother and also Past-President H. F. Moore, who came from Urbana with the medalist.

New Committee on Quality Control of Materials to be Organized

THE growing importance of quality control of materials by the application of the principles of statistical analysis and in other ways has led the Executive Committee of the Society to authorize the appointment of a new technical committee in the "E" group on this subject. The Society's direct interest in the subject of quality control is, of course, in its relation to the development of standard methods of test and specifications for materials, and it is upon this aspect of the subject that the new committee will devote its principal efforts. Applications of the principle of quality control were an important factor in speeding up production of war matériel and constitute an important "tool" in the development of the specifications of the future.

One of the important objectives in organizing the new committee is to provide in the Society a place where this subject and its application to the work of the Society can be studied and the results of that study brought out in suitable publications. The committee is intended also to act in an advisory capacity to the other technical committees of the Society.

It is planned to place under the jurisdiction of the new committee the related subject of interpretation and presentation of data, concerning which the Society through Committee E-1 on Methods of Testing did much work of a pioneer nature beginning some fifteen years ago. The Manual on Presentation of Data that developed from that work has been widely used throughout the Society and in industry and can now be revised and supplemented in the light of recent developments in a way that will add still more to its usefulness. It is further planned

to transfer to the new committee the related work on designation and interpretation of numerical requirements, which has also been under the guidance of Committee E-1.

Harold F. Dodge, Quality Results Engineer, Bell Telephone Laboratories, Inc., New York City, has accepted the chairmanship *pro tem* of the new committee. Mr. Dodge has had many years of experience in this field of work and is still the chairman of the subcommittee of E-1 that developed the Manual above referred to. He will be assisted in the work of forming the new committee by a small organizing group whose personnel will be announced later.

E. U. Condon New Director, National Bureau of Standards

DR. EDWARD UHLER CONDON, formerly Associate Director, Westinghouse Research Laboratories, has been appointed Director of the National Bureau of Standards, Washington, D. C., succeeding Dr. Lyman J. Briggs who has been Director since 1933. Dr. Briggs, who was born in Michigan in 1874, had received honors from many universities. He has taken very active interest in work of various organizations including A.S.T.M. In the U. S. Department of Agriculture from 1896 through 1919, he became Chief of the Division of Mechanics and Sound at the Bureau and was Assistant Director of the Division of Research and Testing for a number of years.

Dr. Condon, a native of New Mexico, received his A.B. and Ph.D. degrees from University of California in 1924 and 1926, respectively. Later he was on the faculties of Princeton and the University of Minnesota, serving as Associate Professor at Princeton until in 1937 he joined the Westinghouse organization.

Research Revolutionizes Materials¹

By J. R. Townsend²



This and other photographs in Germany, by J. R. Townsend
Part of Devastated Nuremberg.

As one awakens in the morning, returning to consciousness causes one to be critical of his surroundings. This was vividly impressed upon me this past summer while in Germany. The night previous I had arrived at the ancient city of Nuremberg and being very tired had gone immediately to my billet, rolled up into a bedroll and to sleep.

Dawning consciousness revealed unusual sounds and odors. There was the incessant patter of feet on pavement, the sound of light wheels rolling, and the sharper clomp clomp of wooden shoe soles; no voices, no whistling, no signs of levity. I walked to the shattered window and looked out over devastated Nuremberg.

The footsteps came from the women of Nuremberg plodding patiently, alone, with impassive faces, pushing baby carriages, toy wagons, wheelbarrows, bicycles, all bent on going out of town to the country to barter for cabbage and potatoes.

Their men were dead, wounded, or behind barbed wire. The army of occupation was aloof: no fraternization with any German, no fuel, little water, no transportation.

The odor was of wet plaster—rubble—mildew—and death. The ancient walls of the old town, built of red sandstone, were badly scarred but still standing; the bastions and block houses had their tiles stripped from their roof beams like fish scales. Inside the walled city the ancient buildings were rubble. Destruction was complete. There was a bulldozer path down the middle of the old crooked streets. Over this path the women went on their journey for food. On the wall across the way was written in German, "In twenty minutes, one thousand years have passed,"—it can now be done in less than a second by an atomic bomb.

One might ponder on the survival of hand-wrought masonry when all other forms of construction, ancient and modern, were waste; on the powerful weapons of modern design based on science that have destroyed a citadel built by hand; or on the technological culture that

had allowed us to triumph thus over our enemies. Unquestionably Germany was defeated technically more by the overwhelming number than by the individual superiority of our arms. The miracle of American production is based on a design related to obtaining the most from the process used, materials of uniform quality and high-speed production methods using high power and automatic machinery. Germany's mistake was to standardize too early and too inflexibly, which prevented taking advantage of improvement in the art. They also lacked understanding of design for the use of high-speed production methods. Slave labor could not compensate for this lack. And hand files and fit, however expert, could not compete with American broaching machines, multispindle drill presses, and automatic welding methods. The improper use of process, the improper use of standardization, and lack of quality control had defeated a nation strong in science, with many new weapons and years of preparation for war.

SCIENTIFIC PROGRESS

It is profitable to take stock of the fundamentals involved in this problem. Science is now a matter of national concern. New materials and processes are the lifeblood of progress and the Endless Frontier of which Vannevar Bush writes in his report to the President. I propose to examine this subject briefly and by tracing the experience of A.S.T.M. in the field of materials development determine trends and the direction in which our technological thinking must go.

Modern science is based upon the reproducible test. Its method is briefly to control all variables except the one under examination. This experimental method far outstripped the former "cut and try" methods. The methods of modern experimental science have been most powerful in supplying us with a fuller and more exact knowledge of

¹ Presented at A.S.T.M. District meetings in Chicago, October 24; Detroit, October 25; Pittsburgh, November 29; and Cleveland, December 4.

² Materials Engineer, Bell Telephone Laboratories, Inc., New York City; and President, American Society for Testing Materials.

nature and have provided the exact data with which to plan and build. Engineering may be said to have preceded science, since the ancients built houses and dams and forts without knowing much about the materials used. They were natural materials and readily at hand. They were largely shaped by hand or with simple tools using labor of man and beast. In the last three or four generations, modern science with its experimental methods has greatly enriched our power to shape materials and forces to our needs. Science and technology now run abreast.

Progress in science is based upon research. Research is a natural human expression and involves man's curiosity about his environment. Scientific research may be divided into *basic, fundamental*, or *pure research* on one hand and *applied science* on the other. Between these extremes is a vast ocean of accumulated knowledge and experience. *Basic research* is concerned with new principles and new conceptions, the understanding of Nature and its laws and generalizations. Basic research is also concerned with techniques and methods of making reproducible tests. Basic research is most often done without thought of specific practical ends.

Between basic research and applied science there is a great amount of accumulated knowledge, data, and art. Research has to do with the collection of vast masses of data from many carefully controlled tests and measurements. Indeed research is principally concerned with the collection of these data. Engineering design is based both upon natural laws and upon the data that have been collected by all the investigators working in a particular field. Not only must we have a reproducible test, but there should be sufficient data to satisfy the laws of chance or probability that the measurements are under control and reliable. Accumulated data may involve an integration of several interrelated effects; for example, a corrosion test or an electrical contact wear test. Such tests produce data upon which judgments may be based, but may not yield fundamental information

concerning the cause of the phenomena being measured.

Applied science uses techniques, processes, and empirical tests. Oftentimes much progress can be made from simple observations of behavior in specific environment. This is frequently described as experience. Progress can be made with experience knowledge, but it is very limited, inefficient and does not give information on causes. If we know these causes then we may shape things better to serve our ends. Except in textbooks and discourses of this kind there is no sharp line between pure scientific research, the accumulation of data or specific experience. Furthermore, orderly scientific methods, discovery and invention are intermingled and indistinguishable.

A.S.T.M.—FURTHER CONTROLS OF QUALITY

The American Society for Testing Materials came into being at the turn of the century and it may be said to cover the greatest or most active period of the development and use of scientific knowledge applied to engineering materials. Its objectives are the promotion of knowledge of materials and the standardization of specifications and methods of test. The usual procedure is the development of methods of test, followed by the collection of data, and then the arrival at specific requirements controlling the useful quality of the material. Modern industry is based upon such specifications because materials must have controlled quality to be useful in modern production methods. Future industrial methods will require further controls of quality as we utilize our science more efficiently.

Let us see why this is so. The industrial revolution came into being with the automatic turret lathe. The machine was devised to make a series of operations automatically. The machine has no judgment and hence it is fixed to perform each operation and sequence of operations the same way each time. In order to obtain interchangeability one must have every part exactly alike, and with the invariable machine the quality of material must be uniform and

under accurate dimensional control. Of course, there must be allowances for fit of parts and tolerances to compensate for the unavoidable variability of the product, wear in the machine, etc. Modern statistical methods applied in a scientific manner have gone beyond guaranteeing a uniform product. They can show trends which can be associated with causes and these in turn can be corrected or adjusted before the product drifts beyond the requirement or is out of control.

MATERIALS RESEARCH

The work of A.S.T.M. broadly covers research in the field of materials. Our research work deals mostly with the collection of data which are of vital importance in establishing suitable tests and specification limits or standards. However, basic or fundamental research has been carried out in a number of fields, and furthermore many experience data have been collected and reported. A few examples of this work would be in order.

An example of basic research under the auspices of A.S.T.M. committees is research on fatigue of metals. The first comprehensive reports on fatigue of metals by a large group of laboratories appeared in our *Proceedings*, the reports having been prepared under the guidance of the Research Committee on the Fatigue of Metals. The many papers were concerned with the relation between fatigue strength and related properties of metals and their atomic and crystalline arrangement. Notable items were papers by H. F. Moore on "Stress Strain and Structural Damage"³ and "Stress-Strain Cycle Relationship and Corrosion Fatigue of Metals" by D. J. McAdam, Jr.⁴

Another example was the Joint Research Committee of A.S.T.M. and A.S.M.E. on the Effect of Temperature on the Properties of Metals. Notable efforts by this committee have been the 1931 Symposium on Effect of Temperature on Properties of Metals, an 829-page book, the volume on Creep Data, 1938, and "Impact Resistance and Tensile Properties of Metals at Subatmospheric Tem-

³ *Proceedings, Am. Soc. Testing Mats.*, Vol. 39, p. 549 (1939). (Edgar Marburg Lecture.)
⁴ *Ibid.*, Vol. 26, Part II, p. 224 (1926).

... The benefits (from A.S.T.M.) extend to vast improvements in process methods, more uniform and higher quality and result in economic gains of an extensive character.

peratures" from data supplied by the committee and other published data collected by H. W. Gillett, August, 1941.

In the field of the collection and correlation of background data, over a hundred projects could be cited. A few of these will suffice for examples, including Committee A-5's report in 1937 on "Atmospheric Corrosion Tests on Wire and Wire Products." This included unfabricated wire, barbed wire, wire strand, farm field fencing and chain link fence started in 1936 at eleven test locations from coast to coast. The Wire Test Reports of 1937 and 1939 and the Report of 1943 give the original data and the six-year results. Similar test reports are available on non-ferrous metals, die castings, galvanized sheet iron, zinc-coated hardware, and copper-bearing and noncopper-bearing uncoated steel and iron sheets.

Examples of applied science within the scope of activity of A.S.T.M. are the development of techniques for radiographic testing and spectrographic analysis, methods of indentation hardness testing, and methods of measuring permanence properties of plastics such as color fastness, water absorption, resistance to chemical reagents, water vapor permeability and flow temperature of plastics.

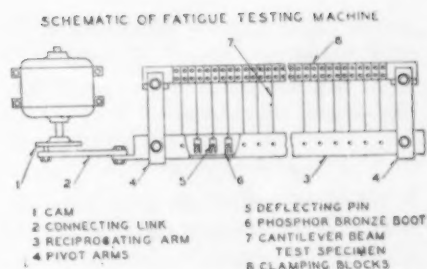
The benefits from research with materials do not stop with the creation of a good test method and the promulgation of specification limits. Neither does the influence of A.S.T.M. stop here. The benefits extend to vast improvements in process methods, more uniform and higher quality and result in economic gains of an extensive character. The development of a good test method permits us to judge the value of changes in process and the influence of each particular factor in its physical creation. As the test methods become more precise, more basic and more

rigorous in application, all of these benefits become proportionately greater. Because of this trend and since new products must be found at the frontiers of science, scientific research has now teamed up with technology in the creation and discovery of new and useful products. Indeed this trend is rapidly accelerating, and we must closely follow basic scientific literature if we are to remain up to date in the development and use of materials. In fact, engineering demands are so great today for better materials and processes and products that basic scientific research is being pressed for results. This is a temporary condition brought about by the war and it is clear that our scientists will return to basic research now that the emergency has passed.

To show the broad influence which scientific research directed at materials has on economics, I will cite three examples from my own experience in the work of A.S.T.M. These three examples are the development of physical tests for brass sheet, die castings, and the development of an electrical system for the classification of mica.

SHEET BRASS

Following World War I, one of the broad engineering problems in communications was the necessity of providing better telephone service by the introduction of automatic central offices where connections could be made by machinery rather than by hand, since a sufficient number of suitable operators could not be found. Millions of switches, comprising thousands of identical parts, were required. Manufacture by progressive punch and forming dies was indicated. Close spacing demanded close allowances and tolerances. Tools and high-speed production methods could be devised from existing art, but sheet brass of sufficiently uniform quality was not available. Our first approach was to determine methods of test for sheet brass because only in this way could we judge the value of improvements. Hard and spring temper brass, 0.007 to 0.030 in. thick, was involved. Methods of making tension tests and hardness tests for such



material were unknown. There were no data relating punching, forming, hardness, fatigue (see illustration above), creep, reversed bending with temper and grain direction. Basic manufacturing processes of annealing and rolling schedules required revision. Thickness tolerances of the finished sheet metal had an important bearing upon the tension and adjustment of switch contacting springs made from it. Two brass companies cooperated in the work and many engineers were involved both in the laboratory and the shop. Later this work was reported through A.S.T.M. to the industry as a whole and finally the work was reviewed and revised by Committee E-1 on Methods of Test and Committee B-5 on Wrought Non-Ferrous Metals. The work has since been extended to nickel silver, phosphor bronze, beryllium copper and other alloys under the auspices of these committees.

There has resulted the use of the Rockwell hardness test for control of the hardening of sheet metal and the correlation of Rockwell hardness with Vickers and Brinell, tensile strength and percentage reduction by cold work. Round-robin tests have supplied background data from which limits could be drawn. Thousands of tons of non-ferrous metals have been made to these requirements. The art of manufacture of non-ferrous metals has been greatly enhanced.

The correlation data and tables that have resulted from this work have been of tremendous value in the control and specification of cartridge brass. In fact, this work was an indispensable contribution to the war effort and to the science and art of non-ferrous metal control. There has also resulted a decimal system of gage sizes following a preferred numbering system and close tolerance commercial sheet

metal. And thus the requirement of high quality, close dimensioned sheet brass was made available for high-speed machines.

DIE CASTINGS

When we undertook consideration of the replacement of the desk stand with the so-called French telephone or hand set, there was considerable speculation concerning the design of the base involving the cradle upon which the handset rested when not in use. The high cost associated with slow production rate and great number of bases required, precluded the use of sand castings. Plastic molding was still in its infancy. Die casting was suggested as a possible way out. Available alloys were weak and there were no standards in the industry. In fact, die castings were regarded as blow-holes surrounded by cast metal! Disintegrated castings were reported for some of the alloys in service.

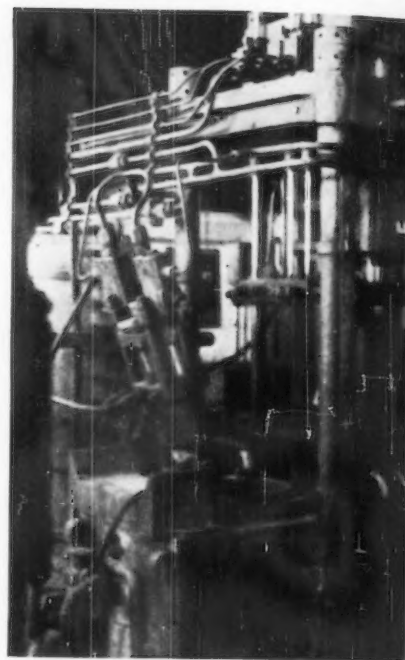
A committee on die castings was organized under A.S.T.M. procedure in 1930. Producers and consumers met on common ground and methods of tension and impact tests were worked out. The principal problem, however, concerned the permanency of die castings. Some die casting alloys of aluminum and containing zinc had been unstable and had resulted in failure in service.

A number of exposure locations were selected throughout the United States and the Panama Canal Zone and samples of two kinds of tension bar, flat and round, and an impact bar were exposed out of doors. Indoor or shelf life tests were also established. Specimens were brought in and tested at one-half, two, six, and fifteen-year intervals.

The fifteen-year tests have just been completed. Zinc base or Zamak alloys were developed, also followed by improved aluminum alloys, magnesium base, brass, lead, and tin alloys. With the Zamak alloys there came into being the steam chest test for proving the stability of castings. Many people have cooperated in this work and there have resulted die castings of high quality, cheap and stable. First aluminum and then Zamak die castings were used for the handset cradle and later for the combined set mounting. A pleasing design, cheap and effective, was created. We have never had a failure of one of these die castings. Millions have been made. Modern statistical methods were used for the first time in evaluating the results of hundreds of thousands of specimens.

Shortly before the war the cold chamber die casting machine came into use. It was more practical for magnesium die castings since the low latent heat of magnesium required a quick-acting casting press. This was accomplished by pouring the metal directly into an ejection cylinder from which it is immediately forced into the die.

The same problem that had confronted us with the telephone handset cradle confronted the nation during the war. High-speed production of such items as fuse bodies was important. The automatic screw machine process in vogue was costly, slow and wasted metal. High-speed turning brass was commonly used. Brass was needed for cartridge cases. If die castings could be used for fuses the partially idle die casting industry could be better employed. Zinc and aluminum could be substituted and



Hot Injection Magnesium Die Casting Machine

we could save brass for cartridge cases.

Whereas we had accumulated much basic science regarding the metallurgical stability of die-casting alloys, tests of quality compliance were needed and much art was involved. There were many die casting plants and some were unfamiliar with technical controls. The WPB requested a committee consisting of David Basch, Robert Waring, Carl Heussner, and myself to visit these plants and certify them to U.S.A. as to ability to produce the high-quality die castings needed for war use. We considered our task was not merely this but that we might be considered technical ambassadors who would induce the industry to use the best alloys, avoid contamination, and apply the best scientific control tests. They were persuaded to use X-ray examination of castings, spectrographic control of alloy composition, use of clean alloys and plant and material handling methods that would guarantee good castings.

There have resulted die castings



A Bombed Die Casting Plant.

One of the World's Largest Die Casting Machines for Experimental Engine Blocks in Germany.



without blowholes, 100 per cent X-ray inspection, for some applications, close composition control; thus the uses of die castings have been extended to accurate and high-quality applications. Some examples are binocular frames, airplane parts, radio parts, and supercharger parts.

In the meantime we gave up Zamak die castings to these war uses and substituted plastics for our telephone, using substantially the same design of dies for injection molded plastic.

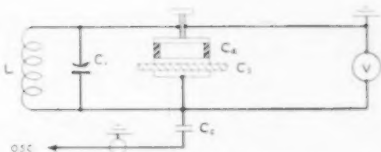
As a partial testimony to our work I might mention that several German die casting plants I visited were using A.S.T.M. alloys. I did not see X-ray inspection or spectrographic control and that is one reason why our castings are better.

I am very fond of this example of research. It shows that the application of the tools and rigorous methods of science has been of direct benefit to our country and to the industry involved.

My third example of research was more closely related to conditions brought about by the direct consequences of the war and bids fair to revolutionize the mica industry.

MICA

When Japan seized the South Pacific islands and closed the gate to traffic to India everyone knows we were deprived of three important strategic materials, rubber, silk and tin. Synthetic rubber was developed in time to replace natural rubber and fortunately Nylon replaced silk. New sources of tin were developed, and the rigorous substitution of other materials for tin resulted in a situation that was tolerable. The story of mica is not so well known. The principal world source of mica was India. Mica was classified according to seven



Power Factor Test Circuit.

visual categories as follows: clear, clear and slightly stained, fair stained, good stained, stained, heavy stained, black stained, and spotted. Capacitors for radio could not be made with mica below third best quality or ruby fair stained. The demand for capacitor mica outstripped all available supply and the WPB entered into a contract with

The latter comprises a one-megacycle resonant circuit in conjunction with a 2-in. diameter flat test electrode. Forming an integral part of the upper moving electrode and connected to the grounded side of the circuit is a fixed capacitor. A vacuum tube oscillator is capacitively coupled and tuned to the test circuit. Resonance is indicated by a vacuum tube voltmeter connected in parallel with the tuned circuit. Oscillator report and tuning adjustments are made to bring the reading of the voltmeter to full-scale deflection. A test sample is placed between the electrodes and screwed

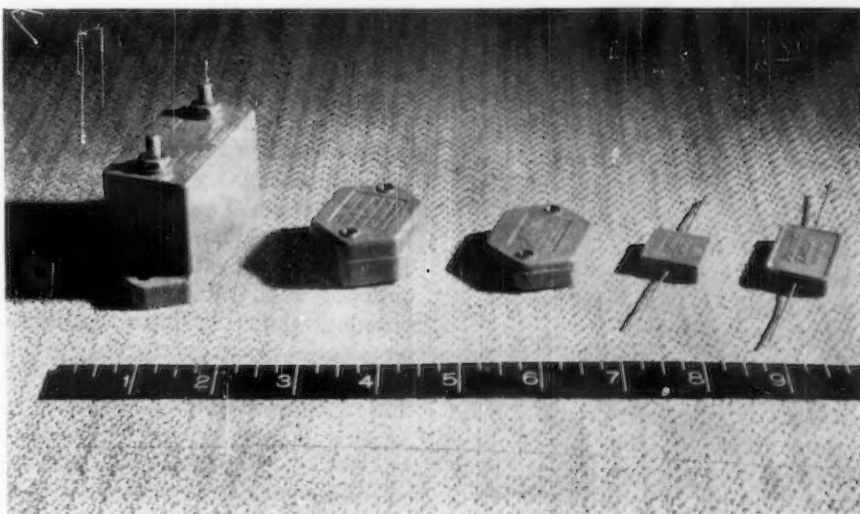


Photo courtesy Bell Telephone Laboratories, Inc.

Samples of 47,000 Capacitors from Eight Manufacturers; Used to Evaluate the Mica Electrical Test.

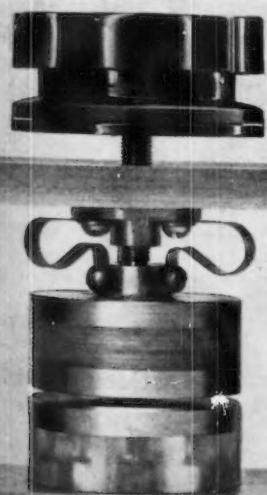
the Western Electric Co. to undertake the development of an electrical method of classifying mica that would be portable and could be carried into the field or to the work bench.

The fundamental yardsticks of quality of mica involved are the absence of conducting particles and a measure of dielectric loss or power factor, usually expressed as the reciprocal of power factor or Q at frequencies of one megacycle. Several methods have been investigated and the one finally adopted consisted first of a simple battery induction coil sparking test and a portable rapid power factor test.

Mica Test Electrodes.

down. One adjustment establishes resonance. The voltmeter scale shows tolerance limits for the mica. Fifteen specimens may be tested in one minute.

Many samples of stained mica which formerly would have failed on the visual tests passed the electrical tests. A trial was made of 3000 lb. of 22 different sources of mica from all over the world. Eight capacitor manufacturers made 47,000 capacitors from mica classified by the electrical method. These capacitors were given life tests under accelerated service conditions. The ability of the test sets to select satisfactory mica was thus established. All of this work has been reported to our Committee D-9 on Electrical Insulating Materials and A.S.T.M. Standard D 748-43 T has been promulgated.



The immediate effect of classifying mica electrically was to permit the use of stained and previously rejected quality. The long-range effect is to eliminate opinion concerning quality of mica and the substitution of a specific electrical requirement. This is an excellent example of basic and background research and the splendid service the auspices of A.S.T.M. provide industry. It was discovered that 60 per cent of the mica formerly rejected by the visual method could be used! An important crisis had been avoided!

TRENDS IN MATERIALS—A.S.T.M. COMMITTEES

In order to determine trends in scientific development of useful materials, it is proper to review the past from which we can determine the course that has been set. There is no better way of doing this than to analyze the work of A.S.T.M. committees since the turn of the century. Considerable technical interest must be developed before a committee is formed.

In the field of metals, A-1 on Steel was established in 1898, Committees on Cast Iron in 1903, Wrought Iron in 1909, and Malleable Iron Castings in 1918. The Committee on Ferro-Alloys was formed in 1923 and on Stainless Steels in 1928. The communications industry was early interested in standards and we find the technical group on Copper Alloy Wires for Electrical Purposes was formed in 1909 along with the Committee on Non-Ferrous Metals and Alloys. We then have groups on Electrical Alloys in 1925, Light Metals and Alloys (aluminum, magnesium, etc.) in 1928, and on brass and similar alloys in the same year. Committee B-6 on Die Castings came into being in 1930 and eleven years later the Committee on Electro-Deposited

Coatings was formed, followed by the group concerned with Metal Powder and Metal Powder Products in 1944.

It is interesting to note that progress has established ferrous and non-ferrous alloys, stainless steels, and light metals in the order named. Recent progress in metals has surrounded processes of die castings, electro-deposited metals, and metal powders. From present trends I would judge that vapor-deposited metals or metals deposited or combined with other metals in the vapor phase will be the next important field of investigation. Progress in this direction is already being made in scientific laboratories here and abroad.

Progress in building materials is equally interesting. Committee C-1 on Cement was organized in 1902 along with the Committee on Paint and Varnish. Our Committee on Road Materials was established in 1903, on Clay Pipe in 1904, and on Timber in the same year. Other materials such as bituminous waterproofing materials, drain tile, lime, refractories, concrete, gypsum, building stones, mortars entered the standards field up until 1931. At this point a change in course was noted. Most of the building materials were now accounted for but new committees were formed on concrete pipe, glass and glass products, and thermal insulating materials. We see that products and not bulk materials have appeared in the building field.

A similar metamorphosis has taken place in chemical materials. For example, Committee D-2 on Petroleum Products was formed in 1904 along with the group on Coal and Coke. Our technical committee on Electrical Insulating Materials was organized in 1909, committees on Rubber and Rubber-like Products in 1912, Refractories in 1914, Naval Stores in 1924, Water for Industrial Uses in 1932, Gaseous Fuels in 1935, Soaps and Other Detergents in 1936, Plastics (one of our most active groups) in 1937, Industrial Aromatic Hydrocarbons in 1943, and finally Committee D-14 on Adhesives in 1944. The trend here is from fuels and lubricants, rubber and plastics, soaps and solvents to adhesives. Adhesives

... We have drained the barrel of available basic science. Our immediate task is to refill the barrel. In the meantime technology is pressing basic science for new materials and processes. Scientific research emerges as a teammate of technology. It is our job as good Americans to do our best to aid the evolution of a better material civilization.

will have application to composite materials.

The trend in methods of test is from a general committee on Methods of Testing formed in 1904 to Metallography in 1916, Corrosion of Non-Ferrous Metals and Alloys in 1922, Spectrographic Analysis, 1932, and Radiographic Testing in 1938. Present trends and interests are in the direction of the mass spectrograph, the infrared spectrograph, and the electron microscope. The trend is for the engineer to use more and more the tools of basic physical science.

There have been organized very recently committees on consumer goods and on parts and assemblies such as sandwich materials, this latter group to concern itself especially with simulated service testing. As a result of the stimulus of the war, great strides have been made in process and fabrication. It is to be expected, therefore, that the immediate future will see an age of prefabrication and process development. Labor will thus have more power at its disposal and will produce more than by conventional methods. We have drained the barrel of available basic science. Our immediate task is to refill the barrel. In the meantime technology is pressing basic science for new materials and processes. Scientific research emerges as a teammate of technology. It is our job as good Americans to do our best to aid this evolution of a better material civilization.

... Modern industry is based upon (such) specifications because materials must have controlled quality to be useful in modern production methods. Future industrial methods will require further controls of quality as we utilize our science more efficiently.

Address by C. F. Kettering

Standards, Research, Paints, Pistons, Malleable Iron, Automobiles, Museums, Machine Guns, an Atheist, and Numerous Other Interesting Subjects

EDITOR'S NOTE: Received enthusiastically by more than 900 people at the Detroit Meeting, this address undoubtedly will prove interesting, entertaining, and thought provoking to all who read it. Mr. Kettering's own individual style of presentation has been retained in this printing.

This address was preceded by President Townsend's on "Research Revolutionizes Materials" which is published in this BULLETIN on the preceding pages.

I AM very much interested in the talk your President just gave, because I don't think you could have had two people on the same program who look at "Research Revolutionizes Materials" from such totally different points of view as he and I.

Mr. Townsend told you about the importance of standardization, the importance of practical tests, and what they mean to industry. Now anyone who has been in mass production, or the duplication of parts, knows that the work of your great Society can never be overestimated. However, from my viewpoint, all of the things you do are not good, because sometimes standardization and methods of testing become static.

A poor inventor like myself, when he goes to get something that is different, cannot get it because it has all been standardized, the tests are all made. So he may have trouble getting a few samples that he wants for his particular work. These samples will usually be the worst things you can get. The fellow who makes them up for you thinks you are screwy because you want something that is not standard. So he usually makes the samples up so they are no good and you will not be able to use them. Then we have to undo all that.

We were working at one time trying to get some very, very, high duty steel. People had talked about

compressive strengths of 200,000 psi. and we wanted to go on up. We wanted to go to about 500,000 or 600,000 psi. There wasn't any such thing as that, so we talked about it, and finally persuaded a certain concern to make us a couple of pieces.

Well, the first pieces they made and sent through were too soft, they just indented. So we told them, "The next time, won't you please make them hard?" So they did. They made them so hard they broke in shipment; then we had to go back and say we didn't want them quite that hard.

They said, "What in the hell did you ask for a lot of stuff that wasn't standard for, anyhow? Why didn't you ask for something standard?"

There were many times during the war when we could not get the things we had before, and we had to take something else. Take the matter of paints and varnishes. We have had a very interesting experience with them, in trying to standardize tests on paints and varnishes; and in trying to work out the thing called weathering. Most of our automobiles stand outdoors, so weathering is important.

The people in south Florida said that any failures that happened down there were due to their magnificent sunshine. They said no one ought to kick about an automobile finish failing down there, because you got something back for it, got plenty of sunshine. So about sixteen years ago we put in an exposure laboratory at Coral Gables to check the durability of paints. This laboratory was installed just about the time we went from the old-fashioned

piano finishes to the more modern Duco and Dulux finishes.

We ran tests and tests and tests, and finally I said, "They don't seem to mean much." So we started in to instrument the thing. We made a sunlight recorder to help us find out how much sun energy fell on a plate per day, and how much it had to do with the failure of the finish. After a number of years, we got a pretty good record. We found out that paints did not fade in certain kinds of light, so we worked out a scale and developed a new instrument. At the end of the first year with the new instrumentation, we found that paints failed just exactly opposite from what everybody thought they did! That is, the hotter the sunlight the less they failed, which didn't seem right.

Two things brought this about. First of all, there had been a standard method of testing which said that a test plate was to face 45 deg. to the south. That is all right in the wintertime in Florida, but in the summertime shadows are cast to the south. So in the summer the sun didn't shine on the front of the plates at all, it shone on the back of them. They forgot to put latitude into this test.

We finally found that if you took two sets of plates and put one set out at six o'clock in the morning and took it in at six o'clock at night; and put the other set out at six o'clock at night and took it in at six o'clock in the morning, the set put out at night failed about four times as fast as the set put out in the daytime. That began to weaken the sunlight theory.

Now after all that—remember, the process was quite detailed—we found that the sunlight didn't have anything to do with it, that it was nothing but just plain, ordinary dew, so we developed some dew-meters.

We set up three rows of plates. One row had a couple of incandescent lamps behind the plates. That

¹ Vice-President, General Motors Corporation, and General Manager, General Motors Research Laboratories Division. This address was presented at the A.S.T.M. Detroit District Meeting, Rackham Building, October 25, 1945.

kept them warm so they never had any dew on them. We had another row just normal. The third row had little refrigerating coils behind the plates, so they got a lot more than normal dew. With that very simple scheme, we could determine what percentage of the time they were wet with rain or dew. Our dew-meter is a little piece of wick laid on the face of each plate and held down with two carbon brushes. When the wick gets damp it starts a current through a micro-relay hooked up to an accumulating clock.

Well, things began to check, then. I mean the plates failed just in proportion to the number of hours of dew. So then the question was asked, "Well, now what is the difference between wetting a plate with rain and wetting it with dew?" There is just the difference between the paint staying good and failing, which is quite considerable.

However, we think maybe the sun does have a little something to do with it. When these plates are exposed in the daytime, they get quite hot. Take a plate painted black, for example. Normally the Florida sun in February will run up to around 185 F. Now that temperature will expand the metal. If it expands the metal faster than the paint can expand along with it, you get a lot of cracks. Then when the plate cools down at night, you have a lot of little places where the dew can get in. The dew starts from the bottom up, because that is the coldest place, and so you get the cracks filled up.

If you spray, the water just bridges over the top, and you never get it down in the crack at all.

So out of that we found you did not have to worry about ultraviolet light; only how many hours the plate was wet with dew.

Well, that was rather disconcerting. We did find, however, that the sun has something to do with colors, which are all supposed to be affected by ultraviolet light. Colors sometimes faded worse under glass than they did outside, and the glass wouldn't pass any ultraviolet!

So you have to examine the age of your system, ask how long has this code been in existence? If it has been in existence more than four or five years, I'd question it, because

maybe some new things have come along in that time.

Now there is nothing wrong about that system at all, because as you advance you uncover new things. It is just like in the spectrum. When you use an ordinary spectroscope, you get a line. Well, when you use a better spectroscope you find there are two lines; and when you use a still better one you find there are four; and when you use a super duper deluxe one you perhaps have ten lines. That is the way you want to do.

Things grow exactly that way. They come into the picture with the best information available, and then they have to be pulled apart, and then pulled apart again and again. I think that the question of continually questioning whether or not the standards could be improved is very important.

Sometimes when you make a standard, you set up things that rule other things out. We have gone through one in connection with our Diesel locomotives that has been very interesting.

We started out with certain types of pistons and rings. Everybody seemed to be perfectly happy to change them at sixty or seventy thousand miles. But I was very unhappy that they were happy about it, because I said, "Well, why do you think that is good?"

"Well," they said, "Sixty-five or seventy thousand miles is quite a distance, and that is about all you can expect a piston to do."

I said, "Why?"

"Well," they said, "Just figure how far that piston ring has to travel up and down."

I think it worked out that it travels almost as far as the train does. But I said, "What has that got to do with it?"

They said, "Well, if you were dragged sixty thousand miles over a surface, maybe you would want to be changed, too."

So we tried to find out some things and we discovered a mystery. Where the top piston stopped it always eroded, and the cylinders would wear a little groove where the top ring stopped. I can show you a stack of papers four feet high on all the theories in the world as to why that is.

We said, "Well, let's see if we can measure something in there."

So we finally did. We found out the reason it eroded was because it got too hot. No one had ever measured the temperature because, although it was a fairly simple thing, it was rather difficult to do. So after we discovered heat was the cause of the erosion, we developed an entirely new type of piston and a new type of ring. We have records of the new type rings that have run 750,000 miles. All of our pistons are discarded at one-and-a-half million miles. I don't know why we do that. They seem to be as good as when they started out, but that distance is beyond the limits the experts think they should go.

Now here is an amazing thing. We took one of the old type pistons that had run seventy-five thousand miles before it had to be changed, and sawed it in two, including the rings. We also sawed a new type piston that will run a million-and-a-half miles. To make things interesting we set a card in front of each piston. The card in front of the old type piston read, "This aluminum piston cost \$100." The card in front of the new type steel piston read, "\$50."

Everyone that looked at the display said, "Well, that \$50 piston is no good. I wouldn't use that piston if you gave it to me." Then we had on the back of the card what they did.

The fellows said, "You can't tell me that, because I can tell by looking at them that this \$50 one is no good."

I said, "How do you know by looking at a piston whether it is any good or not? Were you ever a piston in a Diesel engine?"

It was not a question at all of whether the piston was aluminum or steel or this or that. It was a question of taking a set of standards that had been developed in one case and trying to apply them in another. So in spite of standards, you have to be questioning all the time.

In our work on the standardization of fuels, we have found at least fourteen errors in the International Critical Tables, because people have gone through the motions that should give you a pure material but didn't.

We should not neglect or reject the standards for production work, because that would be perfectly foolish. One of the things we get into, when we try to introduce a thing that is different from what has been regarded as basic, is, "Well, now you can't tell us that," or "You can't do that."

Talking about fuels, someone got the idea that you couldn't have more than 100 octane fuel. I said, "That is just like going to the store and saying you can't buy more than one yard of goods, because they have only a yardstick. You would have to have a two-yard stick if you wanted to buy two yards."

So after you get to 100 octane, you go to what is called performance numbers. 120 performance number is a fuel that performs 20 per cent better than 100 octane, so we get a complete break there. The best fuel we had during the war was about 150 performance number.

We have produced, in the past few years, a new type of fuel, trimethyl-butane, or Triptane. This new fuel is about 500 performance number. And, in working that out, you get into many factors that apparently don't add up. Here is what I think is the cause of some of these difficulties: If you have two things or lines that are not quite parallel, they will cross somewhere if their lines are projected far enough. Suppose the top line is *A* and the lower line is *B*, and that *A* has always been above *B*. No one has ever seen it any other way. Consequently, everything is written on that basis. But suppose you cross the intersection and go to the other side. Then *B* is always above *A*. And that is where you get into a lot of trouble.

When we tried to make this new fuel, it was difficult. Not because it should be, but of the nine groupings made up of seven carbon atoms and sixteen hydrogens that are possible, eight of them occur to some extent in natural petroleum. We have never found the ninth in natural petroleum. But everyone tried to make this ninth one work like the other eight, and he was on the other side of the intersection and did not know it. All you had to do was stand on your head, which is a good thing to do when you are doing re-

search, and look at it that way.

People are interested in research for a good many reasons, and there are three ways you can do research. You can do it as the gambler does it and say, "Let's build a research laboratory, put a little money in it and maybe something will come out of it." There is quite a little bit of that done. Or the sales department says, "Research is quite the thing; we ought to have a nice research laboratory and have everything nickel-plated, then we can bring our customers in and show them how good we are." Then there is the research laboratory which really tries to find out something about what is wrong with the product, to see if they can fix it, or to make a new one.

The word "research" to me simply means an organization that doesn't know, but is willing to try to find out. That is all the word "Research" means. In the extending of these facilities, many research laboratories are built for any one or any combination of these three things.

When people come and talk to us about a research laboratory, we say, "What do you want to find out? What is your project, first?" Then we say, "Well, if you have got a good project, if there is something you want to find out, that is all right. Then you ought to get a fellow that thinks it is possible to find that out. That is very important."

Then you should have facilities. But in a great many cases, that is not too important. There are two ways, I say, that you cannot find anything out. If you have absolutely no money, or if you have a little bit too much. I would sooner run a research laboratory on not having quite enough money because then you do more thinking, and you don't rely so much on the facilities. After all, problems are solved in some person's head, someone to get it straight and then work it out.

So there cannot be any sharp demarcation, as Mr. Townsend said, between the so-called pure science thing and the microphone you are talking through, because there is an unbroken continuity. Once in a while we want to try to break that continuity and pull things out inde-

pendently of others, which is a very difficult thing to do.

The reason we are going out of town with our new laboratory is, simply, because there are certain things we cannot do and still associate with nice people in a city. The building codes, the operating codes, and everything that should be enforced in a large city like Detroit prevent us from doing certain things we would like to do, but cannot do in our present environment. So we are going out where we have more room and fewer rules.

When the architects started their plans, I said, "Wait a minute, this is an incubator, not a mausoleum." I said, "There may be some rules made out there that will make it desirable for us to move on, because we don't know what we are going to do. The only thing we do know is that there are certain things we would like to work on."

Here is another interesting problem, this question of metallurgy and the effect of small quantities. You all know of the work in our Metallurgical Department on the annealing of malleable iron, where a thousandth of one per cent of tellurium reduces the time of annealing by fifty per cent. We are sure that there are metals, where the addition of a microscopic or a micro-microscopic amount keeps it from corroding or makes it corrode. We have many samples of steel which are bought under exactly the same specifications, but which, when exposed to the weather, have quite different rates of corrosion. So that has to be worked out.

There is so little we do know for sure. The only way we can keep going is always to remember this: We have a marvelous museum out at Dearborn, Mich.; you can go out there and see where your engines came from, where your automobiles came from, where your railways came from, and all the things we use. Then you say, "How did people get along with that old stuff?" I don't know how they got along with it, but I have never heard anybody ever say, "Well, now, regarding these museum pieces we are making today. . . ." Today we are making the museum pieces for the museums of fifty years from now. And these pieces are going to

look just as funny fifty years from now as the ones do today that are twenty-five or thirty years old.

So we don't come to any finality on these things. They are transient. This is just another day in the chain, another mile on the road; and so these museum pieces we are building today, must always be looked at in terms of how they are going to be looked at fifty years from now.

Of course we have a lot of people come around and say, "What do you think the automobile of fifty years from now is going to look like?" I haven't the slightest idea, and I don't care. Let it look the way the people want it to look. Don't try to force it on them.

New things are being discovered all the time. Nuremberg was mentioned by Mr. Townsend, and German manufacturing. I think we have one thing in this country that is so important we don't even realize or quite recognize that it exists. That is the thing we call mass production. It is not understood in any other country I have ever visited in the same way we understand it here.

I was in Dayton before the war started when they brought in some 0.50 calibre machine guns, and they wanted Frigidaire to make them. Well, Frigidaire had never made any guns, so right away they said, "We don't know anything about the gun business."

So I said to them, "That is a good thing. You don't want to know anything about the gun business, because you are not going into the gun business. The guy who designed this gun and proved it out is the man who is in the gun business. All he is asking you to do is make some more pieces like the ones he is going to give you, you don't need to know anything about guns."

I said, "Let's take that gun down into pieces. There are some screws in there. Your screw machine department doesn't have to know anything about guns to make screws exactly like these. Then, after you have a lot of pieces exactly like these here you put them together,

and they couldn't be anything else but machine guns!"

This business of making things exactly like something else to high degree limits, is understood only in this country.

Of course, the people who started mass production or interchangeability or whatever you want to call it, were the printers, because that is all printing is. A fellow writes something; he proofreads it; then it is set in type; and every time the press goes around we get another copy. Whether what he says is any good or not, that has nothing to do with the situation. The printing shows what he wrote on a piece of paper with a lead pencil or a type-writer.

That is all we try to do in research. We try to write some reasonably good copy which, when the public gets it and doesn't like the way it reads, we have to rewrite again. The fact that we rewrite what the public thinks an automobile should be, every year, is one of the greatest assets we have. And it is going to continue to be a great asset, because one valuable thing the American manufacturers have is they aren't afraid to change.

I was talking to a fellow in the airplane business, and I said, "Joe, how near up to date on changes did you get when you quit making airplanes?"

"Well," he said, "I don't think we got any nearer than ten thousand changes of being caught up. But that was awfully good, because one time we were fifty thousand changes behind."

That was exactly what they couldn't do in Germany. They couldn't get one hundred changes behind and keep going, because they didn't know how. Of course, when you get fifty thousand changes behind, one or two more don't make any difference. But the very fact that we were able continually to be adding, learning from the field and putting what we learned into practice, that's what counts. I was in one plant where the modification center was twice as big as the plant.

That is all right, too. We can do that here because we understand the process of recognizing that particular applications require certain things. If you try to make the special things in the main factory you ball everything up.

Now we know something about printing, and that is all that mass production is. You must have the right kind of paper, the correct kind of ink, and you have to have standardized copy of some kind.

Now as for this kidding I have done about the inventor having to fight standards. Don't ever let that dim your enthusiasm for establishing the best production materials that it is possible for the world to get today, but have somebody questioning them all the time. You don't need to let these people out, you can keep them in the back room some place.

They tell the story about the man who went in to see a cathedral. He had only a short time that day, so he was asked to come back the next day. The fellow who took him through the next day told him how bad he thought the people were that were running the church, how poorly they took care of it, and all that kind of stuff. Finally the man went to the Bishop, or whoever it was, and he asked, "Why is that fellow here?"

"Well," the Bishop said, "that fellow is our atheist. If we ever convert him we are going to have to fire him because he is the only fellow who is finding fault all the time. The reason we have such a marvelous church is because we have that one fellow who doesn't say, 'My goodness, isn't this wonderful?' all the time."

You need to have an atheist, and some more around who will say, "I don't think these standards are any good at all," and he goes back to find out why and bring them up to date.

But it is the very fact that we have these standards, the very fact that we have these processes, that we are here tonight. Therefore, I want to congratulate this great organization on the marvelous job you have done, God speed, and continue your good work.

Proposed Methods for Determination of Dissolved Oxygen in Industrial Waters

Submitted by the Advisory Subcommittee of Committee D-19 on Water for Industrial Uses

An Important Achievement

EDITOR'S NOTE.—Following years of work by outstanding technical authorities, and after many months of discussion and consideration in A.S.T.M. technical Committee D-19, there were drafted the proposed methods described in this article. Because of the nature of this perplexing problem and the importance of the methods, we asked Committee D-19 to prepare a short news article and discussion to accompany the proposed methods, with the result shown here. It should be of interest to every A.S.T.M. member whether or not he is an authority on water analysis or corrosion or embrittlement or the numerous other problems involved.

DEVELOPMENT of methods for the determination of dissolved oxygen in water resulted from recognition of its vital influence on the biochemical purification of waters in streams and rivers. The Winkler method has been most widely used. This method has been found satisfactory for the analysis of natural waters where the requirement is the degree of saturation or the relative concentration, and not a high order of absolute accuracy. Some modifications of the basic procedure were developed to provide a measure of correction for contaminated water but intensive search for more precise and accurate methods awaited the rigorous uses of industrial waters which had been developing in the past quarter century.

The extremely damaging effect of dissolved oxygen on steel has been expounded by many investigators of corrosion. The nature of attack, characterized by pitting instead of general corrosion, as well as the extent of attack have induced many studies of the measurement and control of dissolved oxygen. The control can be either chemical or mechanical, but any appraisal of its effectiveness requires measurement of the amount of oxygen dissolved in the process water.

Many of the most significant contributions to the knowledge of determination of dissolved oxygen have

been made to the Society. Schwartz and Gurney¹ described two multiple sampling techniques in 1934, appending to their paper a bibliography of over one hundred entries covering work in the field from the time of Winkler's first paper.² The next year Schwartz³ proposed the use of sampling tubes instead of flasks in a bulletin of Louisiana State University. White, Leland, and Button⁴ described a distillation method, carefully documenting its limitations, in 1936. Daugherty⁵ in 1937, after a detailed theoretical comparison of the two Schwartz-Gurney methods, expressed a preference for Method B and proposed a method of under-water sampling. In 1943 Adams, Barnett, and Keller⁶ detailed their evolution of both a precision method, suitable for the evaluation of Naval deaerating heaters, and a simple control method for

¹ M. C. Schwartz and W. B. Gurney, "The Determination of Traces of Dissolved Oxygen by the Winkler Method," *Proceedings, Am. Soc. Testing Mats.*, Vol. 34, Part II, p. 795 (1934).

² L. W. Winkler, "The Estimation of Dissolved Oxygen," *Zeitschrift für Angewandte Chemie*, Vol. 24, p. 341 (1911).

³ M. C. Schwartz, Louisiana State University Studies, No. 21 (1935).

⁴ Alfred H. White, Claude H. Leland, and Dale W. Button, "Determination of Dissolved Oxygen in Boiler Feed Water," *Proceedings, Am. Soc. Testing Mats.*, Vol. 36, Part II, p. 697 (1936).

⁵ T. H. Daugherty, "Technique in the Determination of Dissolved Oxygen," *Proceedings, Am. Soc. Testing Mats.*, Vol. 37, Part II, p. 615 (1937).

⁶ Robert C. Adams, Robert E. Barnett, and Daniel E. Keller, Jr., "Laboratory and Field Methods for the Determination of Dissolved Oxygen," *Proceedings, Am. Soc. Testing Mats.*, Vol. 43, p. 1240 (1943).

⁷ R. C. Ulmer, J. M. Reynar, and J. M. Decker, "Application of the Schwartz-Gurney Method for Determination of Dissolved Oxygen in Boiler Feedwater, etc.," *Proceedings, Am. Soc. Testing Mats.*, Vol. 43, p. 1258 (1943).

shipboard use. At the same session Ulmer, Reynar, and Decker⁷ described their application of conductometric titration to Schwartz-Gurney Method B. In addition to the foregoing contributions, most of which are found in the *Proceedings*, Drescher⁸ proposed a temperature-dissolved oxygen curve for the appearance of the starch-iodide color with low concentrations of dissolved oxygen, Perley⁹ discussed the particular application of electrometric titration in 1939, and last year Sebald¹⁰ published three articles on a method closely resembling that of the Navy.

This outline of recent literature on determination of dissolved oxygen does not pretend to be complete but indicates the broad and careful study which has been given to the problem since 1930. Many individuals who have made significant contributions are members of Committee D-19 so that when a subsection of that committee was appointed in 1943 to prepare a standard method for determination of dissolved oxygen it had excellent resources available.

The task of the Dissolved-Oxygen Subsection was somewhat more complex than the usual one of drafting into A.S.T.M. form the most precise and accurate analytical method available. Seldom is a referee method of highest accuracy required for dissolved-oxygen determinations, lower levels of precision and accuracy being acceptable and even preferable for a majority of the determinations which are made. The subsection considered its responsibility to be, therefore, a satisfactory referee method and integration with it of alternate methods for routine, rapid use. An A.S.T.M.

⁸ A. C. Drescher, "Determining Oxygen in Boiler Feedwater," *Combustion*, May (1936).

⁹ G. A. Perley, "Determination of Dissolved Oxygen in Aqueous Solutions," *Industrial and Engineering Chemistry, Analytical Ed.*, Vol. II, p. 240, May 14 (1939).

¹⁰ J. F. Sebald, "Precision Testing for Dissolved Oxygen in Boiler Feedwater," *Power*, Vol. 88, I—p. 298, II—p. 360, II—p. 444 (1944).

method should be both a touchstone, against which the merits of a somewhat different procedure can be appraised, and a text, from which an inexperienced analyst can learn how to make a determination of the desired accuracy. At the same time the procedures and apparatus should be as simple as possible because the practical utility of a method suffers from forbidding complexity and expense.

The subsection first reviewed the methods described in the literature in the light of the members' experience with them. That of White, Leland, and Button appeared to be precise, but offered many practical disadvantages even for a referee method. Although the distillation procedure eliminates the need for measurement and correction for redox interferences and is confined to a single sample, the apparatus is unique and expensive and determinations are tedious. Referee determinations are required for contract-acceptance tests which are a very short part of the life of equipment, so that portable apparatus is highly desirable. The experience of one of the members of the subsection indicated that the method of White *et al* would be unsatisfactory in this respect so that it was given no further consideration.

Since the distillation method cannot be used for elimination of redox interference, it was necessary to select a referee method which provides means of correction for interference. Such correction has been obtained only by double or multiple sampling so that the choice lay between the Schwartz-Gurney and the Navy methods.

It has been shown⁶ that both Schwartz-Gurney methods yield erroneous results when the water contains substances which reduce iodine in alkaline solution but not in acid solution. Ferrous ion is such a substance and its frequent presence in new steel pipe or apparatus renders the Schwartz-Gurney methods suspect for contract-acceptance or similar referee use. This left the Navy method as the tentative choice of the subsection for the referee method.

Before undertaking any trials of the proposed referee method, the subsection considered how alternate

methods could be integrated with it to provide a series of procedures employing the same apparatus. This is important because a user being guided by the A.S.T.M. standard for the simplest determination should not be required to discard and replace a previous set of apparatus when the need for more accurate determinations develops. The proposed referee method appeared to lend itself readily to such a series of three levels. At the referee level, dual 500-ml. samples could be collected, fixed and titrated electrometrically; at the intermediate level, starch titration would be used with dual samples; and for the simplest determinations, a single sample and starch titration would suffice. A laboratory equipped for referee determinations would simultaneously have all apparatus and reagents for more rapid determinations at lower levels, while the laboratory which started at the bottom could progressively equip itself for more precise determinations by adding to the original outfit without the need to abandon any of the apparatus already in use.

Since many laboratories already are equipped with apparatus and follow procedures differing from that toward which the subsection was drawn, it was considered desirable to indicate in the standard the correspondence between the most widely used of these methods and the several levels to be provided. Some cooperative, comparative work on the several methods was required to establish this relationship and this work was conducted in March, 1944.

Each of the four members of the subsection provided an analyst who assembled at a central station of one of the members where it could be arranged to have one of two deaerating feed-heaters operate at constant rate and pressure for the duration of the group trials. It was assumed that maintenance of unvarying operating conditions at the deaerating heater would yield a constant dissolved-oxygen content in the effluent. Upon this assumption it would be possible to determine the precision of any method tried and to obtain confirmatory determinations of the dissolved-oxygen content of

the reagents, but no effort to evaluate the accuracy of the method was planned.

The four analysts made up a team, each with predetermined duties, and by rotation in these duties four analytical teams were provided to obtain comparative results. Team I collected and analyzed a series of five samples, simultaneously obtaining both referee and first-alternate results by recording both the electrometric and starch end points. After the set of five results had been obtained, the duties were rotated and team II made a set of five determinations. One round, five determinations each by four teams, constituted twenty determinations and it was hoped to obtain three or four rounds so that not only the precision of the procedure but that of the several teams could be appraised. One member of the team, assisted by the host member of the subsection, made a series of determinations by Schwartz-Gurney Method B and with the apparatus and starch end point normally employed by the host. The samples for these determinations were not synchronized with the others so that direct comparison between pairs of individual results was not possible.

Unfortunately the automatic controls did not suffice to operate the deaerator so as to maintain constant dissolved-oxygen concentration in the effluent. All steam-driven auxiliaries in the plant exhaust to the line supplying steam to the deaerator and their intermittent operation caused variations in the deaerator pressure. The completeness of deaeration varied inversely with the pressure and so much water was stored in the deaerator that purging of incompletely deaerated water was slow. Consequently the variation in results obtained represented the sum of the variation intrinsic in the method and that of the deaerator itself. This variation prevented the projected redetermination of dissolved oxygen in the reagents. Since the two variables could not be measured separately, it was necessary to measure their joint effect and to consider the result as a conservative criterion of the precision of the method alone.

A complete transcript of all data, notes, and summaries obtained during the five days was circulated to the members of the subsection and considered by them independently and again in a joint conference with the analysts who participated. Statistical analyses of the data permitted some very satisfactory conclusions.

The mean and standard deviation of each of the eight sets of five referee determinations were first calculated. Individual values falling outside the control limits ($\bar{X} \pm A_1\sigma$)¹¹ for each set were discarded as presumably having an assignable cause for their variation. Four values were discarded from the first seven sets for this reason but the mean of the eighth set was greater than the upper control limit for any of the earlier sets so that all of the last five values were discarded. The mean, standard deviation, and new control limits [$\bar{X} \pm (3\sigma/\sqrt{n})$]

¹¹ The methods and symbols used are explained in A.S.T.M. *Manual on Presentation of Data*, Supplement B (1940). Table I, p. 50 of the 1943 Reprint, is particularly useful.

were calculated for the remaining 31 values. The values obtained by starch titrations were treated similarly; first by sets of five; and then all retained values together. The Schwartz-Gurney values were not obtained in sets so that preliminary analysis of these results was not possible. Only values indicated by the analyst's notes as having an assignable source of error were discarded. The mean, standard deviation, and control limits for the remaining values were calculated.

A summary of comparative results of this treatment is given in Table I. These results are not as favorable to the procedures as they should be because of the evident lack of de-aerator control. Even if that influence is disregarded, however, these methods demonstrate a very satisfactory precision. The probable error of the referee method is less than 0.0015 ppm. and that of the first alternate little more than 0.002 ppm. The precision of the Schwartz-Gurney method is of the same order as that of the referee

method but because of the possibility of intrinsic error discussed above it could not be considered for referee purposes.

The balance of the work of the subsection consisted in drafting the standard and agreement on details. The result, published elsewhere in this issue, comprises the three levels made possible with the apparatus and reagents of the referee method. In addition, Schwartz-Gurney Method B, which is probably the most widely used precision method now in vogue, is given as an alternate at the intermediate level. Notes also describe a procedure for the Schwartz-Gurney method using B.O.D. bottles instead of sampling tubes. The use of a B.O.D. bottle instead of a sampling tube for the simplest, rapid determinations is given in detail.

The proposed methods will be considered by Committee D-19 at the 1946 Spring Meeting. Because of widespread interest the method is being published as information and comment of interested members of the Society is solicited. Any comments, suggestions, or criticism which members wish to make should be submitted to Society headquarters by February 1, 1946, for reference to the chairman and consideration by Committee D-19.

TABLE I

	Referee (Electrometric)	First Alternate (Starch)	Schwartz-Gurney
Number of determinations.....	40	39	29
Determinations retained.....	31	33	25
Mean dissolved oxygen, ppm.....	0.0071	0.0080	0.0058
Standard deviation, ppm.....	0.00215	0.00345	0.00190
Final control limits, $\bar{X} \pm$, ppm.....	0.00116	0.00183	0.00114
Determinations within final control limits, per cent.....	35	49	21

Proposed Methods of Test for Dissolved Oxygen in Industrial Waters^{1,2}

Scope:

1. (a) These methods of test cover procedures for the determination of dissolved oxygen in industrial waters. Four methods are given, as follows:

	Sections
Referee Method.....	4 to 9
Non-Referee Method A.....	10 to 15
Non-Referee Method B.....	16 to 21
Non-Referee Method C.....	22 to 27

(b) The referee method covers the procedure for the most precise and accurate determination of dissolved oxygen in all industrial waters. Non-referee methods A, B, and C cover procedures of greater simplicity and lesser precision and accuracy than the referee method.

¹ These proposed methods are under the jurisdiction of the A.S.T.M. Committee D-19 on Water for Industrial Uses.

² Published as information, June, 1945.

Sampling:

2. Detailed requirements for sampling are given in the individual procedures. For general information on sampling, reference shall be made to the Standard Methods of Sampling Plant or Confined Waters for Industrial Uses (A.S.T.M. Designation: D 510).³

Purity of Reagents:

3. Unless otherwise indicated, it is intended that all reagents shall be of the quality known as "reagent grade."

REFeree METHOD

Application:

4. This method is applicable to the most precise and accurate determination of dissolved oxygen in all industrial waters.

³ 1944 Book of A.S.T.M. Standards, Part III, p. 1004.

NOTE.—This method is particularly suited to the exact determination of concentrations less than 1 ppm. of dissolved oxygen. Where the water sampled contains more than 1 ppm. of dissolved oxygen, the high precision of this method may not be required.

Apparatus:

5. The apparatus shall consist of the following:

(a) *Sample Tubes*.—Two glass sample tubes as shown in Fig. 1, having a nominal capacity of 500 ml. The two tubes should not differ from each other by more than 10 ml., and the capacity of each tube shall be determined to the nearest milliliter.

(b) *Burettes*.—Three 10- or 25-ml. burettes, having a stopcock bore not greater than 1 mm. and a maximum tip diameter not exceeding 3 mm.

(c) *Beaker*.—An 800-ml. Griffin low-form beaker.

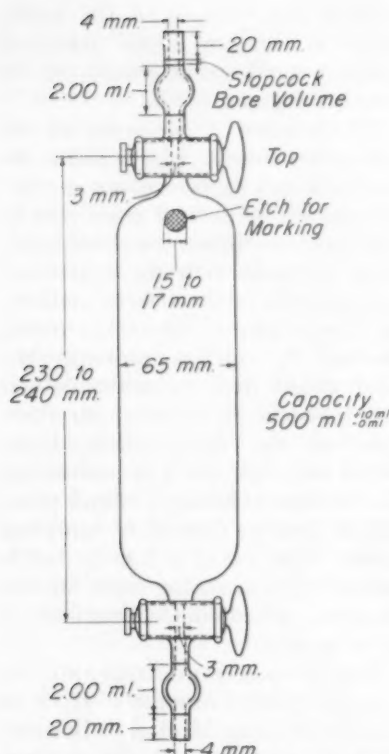


Fig. 1.—500-ml. Sample Tube for Dissolved Oxygen Determination.

(d) *Stirrer*.—A variable-speed motor-driven stirrer with a glass propeller.

(e) *Calomel Electrode*.—Any calomel reference electrode of satisfactory size is suitable. A convenient form is a pencil type made of glass and provided with an external removable glass sleeve at the lower sealed end. This sleeve shall be slightly tapered, 1 to 2 cm. in length, and ground to fit so that the sealed end protrudes slightly beyond the sleeve. Midway of the ground section of the sealed tip there shall be two, small, horizontal holes in register, providing an opening into the interior of the electrode. The electrode shall contain the necessary mercury, calomel, and electrical connection to the mercury and shall be nearly filled with a saturated (20 to 25 C.) solution of KCl, which solution can be replenished.

(f) *Platinum Electrode*.—A length of capillary glass tubing, 12 to 13 cm. in length, with a short length of platinum wire or piece of platinum foil sealed through the lower end and making electrical contact with a column of mercury in the capillary.

(g) *Titration Stand*.—A suitable titration stand to support the stirrer and electrodes so that the beaker containing the sample can be removed easily, and permitting the rinsing of the electrodes and stirrer.

(h) *Pipettes*.—Serological pipettes of 1.00- and 5.00-ml. capacities, graduated in 0.01-ml. divisions.

(i) *Potentiometer*.—A potentiometer having a limit of error not greater than

0.0005 v. and a total range of the order of 1 v. is required. A galvanometer for use with this potentiometer, having an external critical damping resistance of the order of 10,000 ohms, shall be employed in order that current drained from the electrode system may be minimized by the use of an adjustable resistor. A galvanometer having a sensitivity of 0.125 micro-ampere per millimeter division is desirable. The potentiometer may be of the type employing a self-contained galvanometer or of the type using an external galvanometer, as desired. A glass electrode pH meter may be used if equipped with the proper voltage range.

Reagents:

6. (a) *Alkaline Potassium Iodide Solution*.—Dissolve 700 g. of KOH in sufficient distilled water to make approximately 700 ml. of solution in a 1-liter volumetric flask and cool to room temperature. Dissolve 150 g. of iodate-free KI in 200 ml. of distilled water and mix with the KOH solution in the volumetric flask. Dilute to 1 liter with water, mix, and store in a dark, rubber-stoppered bottle.

(b) *Iodine Solution (0.1 N)*.—Dissolve 6.346 g. of resublimed iodine in a solution of 75 g. of KI in 60 ml. of distilled water and dilute with distilled water to 500 ml. in a volumetric flask. Store in a dark, stoppered bottle.

(c) *Iodized Alkaline Iodide Solution*.—Half fill a 250-ml. volumetric flask with the alkaline KI solution. Add an accurately measured, small amount of 0.1 N iodine (Note 1), sufficient to react with all reducing interference in the water to be analyzed when the procedure described below is followed. Dilute to the mark with the alkaline KI solution.

NOTE 1.—While the iodized alkaline iodide solution described in Paragraph (c) must be used for accurate determinations, the minimum sufficient quantity of 0.1 N iodine, as determined by trial, should be used because the precision of the results decreases with increase in iodine concentration. As a trial, use 10 ml. of 0.1 N iodine in preparing the iodized alkaline iodide solution and use on a test run. Prepare a second solution, if necessary, using more or less 0.1 N iodine, depending on the results of the test run.

(d) *Manganous Sulfate Solution*.—Weigh 480 g. of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ into a 600-ml. beaker. Add 200 ml. of distilled water, stir well, and transfer the supernatant solution to a 1-liter volumetric flask. Repeat three times, wash the last of the crystals into the flask, shake until solution is complete, and dilute to 1 liter with distilled water.

(e) *Sulfuric Acid Solution*.—Pour carefully 750 ml. of H_2SO_4 (sp. gr. 1.84) into 250 ml. of distilled water in a beaker. Cool to room temperature, transfer to a 1-liter volumetric flask, and dilute to the mark with distilled water.

(f) *Sodium Thiosulfate Solution (0.05 N)*.—Dissolve 12.42 g. of $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ in distilled water and dilute to 1 liter in a volumetric flask. Determine the exact normality by titration against a standardized solution of $\text{K}_2\text{Cr}_2\text{O}_7$ or $\text{KH}(\text{IO}_3)_2$ (Note 2).

NOTE 2.—If frequent restandardization of this solution is to be avoided, it must be stabilized with an inhibitor. One per cent of potassium furate will limit the decrease in normality to less than 2 per cent in one year, over half of this decrease occurring in the first month. Four-tenths per cent of borax has been used for the same purpose.

(g) *Sodium Thiosulfate Solution (0.005 N)*.—With a calibrated pipette, transfer 25.00 ml. of the 0.05 N $\text{Na}_2\text{S}_2\text{O}_3$ to a 250-ml. volumetric flask. Dilute to the mark with distilled water and mix completely. This solution shall be prepared not more than 12 to 15 hr. before using.

(h) *Starch Indicator Solution*.—Sprinkle 1 g. of soluble root starch into 100 ml. of boiling distilled water. Stir briefly, cool, and decant the clear, supernatant liquid. Prepare fresh daily.

Procedure:

7. (a) *Sampling*.—Arrange the two sample tubes in a support so that they are vertical, and with their upper outlets at the same level. Connect the lower ends to the sampling line by means of rubber tubing and a Y-tube. The sampling line shall contain a suitable cooler if the water being sampled is above room temperature in which case the sample shall be cooled to 60 to 65 F. (16 to 18 C.). If a cooler is used, the valve for cooling-water adjustment shall be at the inlet to the cooler and the overflow shall be to a point of lower elevation. The valve for sample-flow adjustment shall be at the outlet from the cooler. Adjust the sample flow to a rate which will fill the two tubes in 40 to 60 sec., and continue this flow long enough to provide at least ten changes of water in the sampling tubes. If the sampling line is used intermittently, allow a suitably longer time for the first sample to insure adequate flushing of the sampling line and cooler. Close the upper stopcocks of the two tubes simultaneously (Note 1) and immediately close the two lower stopcocks and remove the tubing connections. Invert and examine both tubes to insure the absence of any gas bubbles. If any bubble is discovered, discard both samples and collect new ones.

NOTE 1.—If the line being sampled is under such high pressure that the sampling tubes or connecting tubing may burst with the water hammer when the stopcocks are closed, the sample flow may be throttled with the control valve just before the sample is removed, but the sample flow should not be shut off completely.

(b) *Fixing*.—Fill the three burettes with the iodized alkaline iodide solution, MnSO_4 solution, and H_2SO_4 solution, respec-

tively. Designate one of the duplicate tubes as the *sample* and the other as the *blank*. Refer to Fig. 1 to determine the upper stopcock of the sample flask. Flick the water from the upper nipple (Note 2) of the *sample* flask and fill the nipple to the upper calibration mark with the iodized alkaline iodide solution. Any bubble entrapped in the nipple within or below the reagent can be removed by probing with a clean copper wire until it rises to the surface. Open one stopcock and admit the reagent by control with the other until the meniscus in the nipple coincides with the lower calibration mark. Close both stopcocks and rinse both nipples of the sampling tube with a fine stream of water. Flick out the excess water, invert the tube, and fill the nipple now on top to the calibration mark with the MnSO_4 solution and introduce it into the sample as described for the addition of the iodized alkaline iodide solution. Again rinse both nipples of the sampling tube, shake or rotate the tube to mix the sample thoroughly, and lay it aside. Following precisely the directions given above for adding the reagents to the *sample*, add to the *blank* the indicated amount of iodized alkaline iodide solution through the upper nipple (Note 2) and stopcock, and add the same amount, first of H_2SO_4 solution and then of the MnSO_4 solution, through the lower nipple. Rinse both nipples between additions, as directed above, and mix the *blank* between the second and final addition. Finally, mix the *sample* thoroughly, as directed above, to resuspend the precipitate (Note 3). Add to the *sample* the indicated amount of H_2SO_4 solution, rinse both ends of the flask, and again mix thoroughly. Fixing should be completed within 15 min. after sampling.

NOTE 2.—The upper nipples of both tubes shall be used for the addition of the iodized alkaline iodide solution. The lower nipples shall be used for the MnSO_4 solution and the H_2SO_4 solution.

NOTE 3.—An error is introduced in the determination if the precipitate is allowed to settle so that more than a proportional amount is suspended in the volume withdrawn to permit the addition of the MnSO_4 solution.

(c) *Titration of Sample*.—Drain the *sample* into the clean 800-ml. beaker by opening both stopcocks. Do not rinse or blow through the sampling tube, but shake the last drops from the lower nipple into the beaker. Rinse both electrodes with distilled water, and readjust the sleeve on the calomel electrode to provide a fresh junction. Place the beaker on the titrating stand with both electrodes immersed in the sample, start the stirrer, and adjust its speed to mix the sample rapidly without causing a vortex sufficient to draw bubbles of air into the liquid. Read and record the emf. between the electrodes. Fill the 1- or 5-ml. pipette (Note 4), according to the volume required for the

titration, with 0.005 N $\text{Na}_2\text{S}_2\text{O}_3$, and adjust exactly to the zero mark. Proceed with the titration, rinsing the tip of the pipette in the sample after each addition. Record the cumulative amount of thiosulfate and the emf. after each addition, and make progressively smaller additions as the end point is approached (Note 5) and passed. Titration should be completed within 30 min. after sampling. In a third column, parallel to those for milliliters of thiosulfate and emf., record the quotient

$$\frac{\Delta \text{emf.}}{\Delta \text{thiosulfate}}$$

for each addition. The maximum numerical value of this quotient, without regard to sign, occurs at the end point of the titration. The end point can be identified by inspection of the values in the third column, so that plotting of the data is unnecessary.

NOTE 4.—A burette with 0.01-ml. divisions may be substituted for the pipette, but titrations can be made more rapidly with the pipette.

NOTE 5.—The addition of a few drops of starch indicator solution to the sample, developing the blue color of starch iodide, provides a convenient guide to the approach of the end point. Starch does not interfere with the determination, and the blue color disappears before the end point is reached.

(d) *Titration of Blank*.—Empty the beaker, rinse it and the electrodes with distilled water, prepare a fresh junction with the sleeve of the calomel electrode, and drain the blank into the beaker. Titrate the blank as described for the sample in Paragraph (c).

Calculation:

8. Calculate the dissolved oxygen content of the sample, in terms of parts per million, by either the exact method or the rapid method, as follows:

Exact Method (Note 1):

$$I = \frac{2VN}{Cn}$$

$$D = \frac{6.5}{10,000n}$$

$$X = (S - (I + D)) \times \frac{8000n}{V_s}$$

$$Y = (B - I) \times \frac{8000n}{V_b}$$

$$\text{Dissolved oxygen, ppm.} = X - Y$$

Rapid Method (Note 2):

$$\text{Dissolved oxygen, ppm.} = \left(\frac{16,000n(S - B)}{V_s + V_b} \right) - 0.0104$$

where:

I = milliliters of $\text{Na}_2\text{S}_2\text{O}_3$ solution equivalent to the iodine introduced with the iodized alkaline iodide solution,

V = milliliters of iodine solution used in preparing the iodized alkaline iodide solution,

N = normality of the iodine solution (nominally 0.1),

C = capacity in milliliters of the flask used in preparing the iodized alkaline iodide solution,

n = normality of the $\text{Na}_2\text{S}_2\text{O}_3$ solution (nominally 0.005),

D = milliliters of $\text{Na}_2\text{S}_2\text{O}_3$ solution equivalent to the dissolved oxygen introduced with the fixing reagents (Note 3),

X = dissolved oxygen content of sample uncorrected for blank (Note 1),

S = milliliters of $\text{Na}_2\text{S}_2\text{O}_3$ solution required for titration of the sample,

V_s = volume of sample in milliliters,

Y = correction for blank (Note 1),

B = milliliters of $\text{Na}_2\text{S}_2\text{O}_3$ solution required for titration of the blank, and

V_b = volume of blank in milliliters.

NOTE 1.—With increase in reducing interference in the water sampled, first Y and then X becomes negative. If the algebraic instructions given in the formulas for calculation are followed, the calculated result will be correct.

NOTE 2.—Inaccuracy of the results calculated by the rapid method increases with difference in capacities of the two sampling tubes, the amount of oxygen dissolved in the water samples, and the concentration of redox impurities in the water. Unless these potential inaccuracies are known to be within the required limits of precision of the determination, the exact method of calculation should be used.

NOTE 3.—The factor D is derived from the determinations of Adams, Barnett, and Keller,⁴ and of White, Leland, and Button,⁵ which agree within less than 2 per cent. If there is any question of the validity of the factor D for the fixing solutions employed, the above references may be consulted for methods for determination of the appropriate value. In general, it will be found more economical to discard the questionable solutions and replace them with new solutions prepared from reagent-grade chemicals.

Precision and Accuracy:

9. A skilled operator using this method can obtain results with a precision of 0.002 ppm. and with an accuracy of 0.003 ppm. or 1 per cent, whichever is the greater.

NON-REFEREE METHOD A

Application:

10. This method is applicable to the determination of dissolved oxygen in all industrial waters, when the highest precision is not required.

Apparatus:

11. The apparatus shall consist of the following:

⁴ R. C. Adams, R. E. Barnett, and D. E. Keller, Jr., "Field and Laboratory Determination of Dissolved Oxygen," *Proceedings, Am. Soc. Testing Mats.*, Vol. 43, p. 1252 (1943).

⁵ A. H. White, C. H. Leland, and D. W. Button, "Determination of Dissolved Oxygen in Boiler Feed Water," *Proceedings, Am. Soc. Testing Mats.*, Vol. 36, Part II, p. 707 (1936).

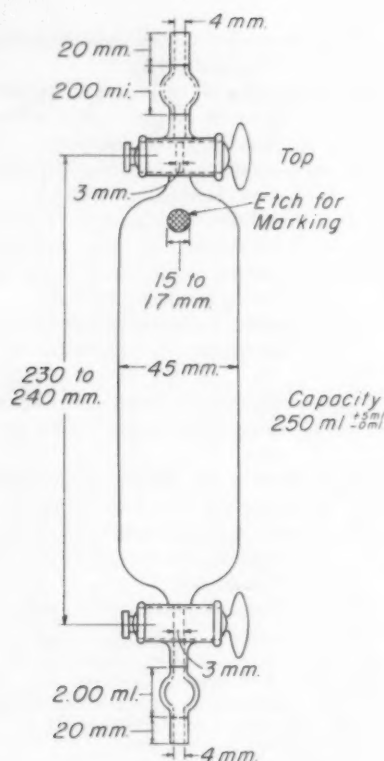


Fig. 2.—250-ml. Sample Tube for Dissolved Oxygen Determination.

(a) *Casserole*.—One 1-liter glazed porcelain casserole, clear white in color.

(b) *Miscellaneous*.—Sample tubes, burettes, and pipettes or burettes, as described in Section 5. The motor stirrer described in Section 5 (d), if available, is of great convenience.

Reagents:

12. For descriptions of the reagents required, see Section 6.

Procedure:

13. (a) *Sampling*.—Collect the samples as described in Section 7 (a), except that a cooling coil shall be provided if the water being sampled is warmer than 60 F. If the temperature of the cooling water is too high to attain this sample temperature, a supplementary cooler, such as a coiled length of copper tubing in a bath of cracked ice or ice water, shall be used. Do not attempt to cool the sample after collection.

(b) *Fixing*.—Fix the sample and blank as described in Section 7 (b).

(c) *Titration of Sample*.—Drain the sample, which shall be at a temperature not above 70 F., into the clean casserole and add 10 drops of starch indicator solution. Fill the 1- or 5-ml. pipette, according to the volume required for the titration, with 0.005 N $\text{Na}_2\text{S}_2\text{O}_3$. Start the motor stirrer, if available, otherwise stir constantly with a clean glass rod. Titrate to the disappearance (Note) of the blue, starch iodide color, rinsing the tip of the

pipette in the sample after each addition as the end point approaches.

NOTE.—Some analysts prefer to titrate to a faint trace of blue instead of to complete disappearance of the indicator color. Such results are subject to errors in judgment of color depth, but avoid the possibility of error by overrunning the end point. The two procedures are equally satisfactory for an experienced analyst.

(d) *Titration of Blank*.—Empty and rinse the casserole and drain the blank into it. Titrate as described in Paragraph (c).

Calculation:

14. Calculate the dissolved oxygen content of the sample, in terms of parts per million, by the rapid method described in Section 8.

Precision and Accuracy:

15. An experienced analyst using this method can obtain results with a precision of 0.004 ppm. and within 0.007 ppm. or 1 per cent of the true value, whichever is the greater.

NON-REFEREE METHOD B

Application:

16. This method is applicable to the determination of dissolved oxygen in industrial waters, when the highest precision is not required and the water is free of contamination (particularly, dissolved iron).

Apparatus:

17. The apparatus shall consist of the following:

(a) *Sample Tubes*.—One sample tube (Note) as shown in Fig. 1, having a nominal capacity of 500 ml. One sample tube (Note) as shown in Fig. 2, having a nominal capacity of 250 ml. The capacity of each tube must be determined to the nearest milliliter.

NOTE.—Four sample bottles as described in Section 23 (a) may be substituted for the preferred sample tubes if the latter are not available. In this case, three 1-ml. and three 2-ml. transfer pipettes must be provided for fixing. Resulting modifications of the procedure are given in Notes 1 to 3 in Section 19.

(b) *Graduate*.—One 500-ml. graduated cylinder.

(c) *Miscellaneous*.—Burettes, an 800-ml. beaker, and pipettes, as described in Section 5 (b), (c), and (h), respectively. A casserole as described in Section 11 (a).

Reagents:

18. (a) For descriptions of reagents that are required, see Section 6 (a), (b), and (d) to (h).

(b) *Dilute Iodine Solution*.—Half fill a 250-ml. volumetric flask with distilled water and dissolve in it approximately 50 g. of KI. Add 10 ml. of 0.1 N iodine, dilute to 250 ml. with distilled water, and

mix thoroughly. Store in a stoppered dark bottle.

Procedure:

19. (a) *Sampling*.—Collect the samples as described in Section 13 (a), using one 500-ml. and one 250-ml. sample tube (Note 1). Collect simultaneously a third portion of at least 250 ml. of the water being sampled. This may be done conveniently by arranging a clean 800-ml. beaker to catch the overflow from one or both of the sample tubes. The collected samples must be at a temperature not greater than 60 F. (16 C.) when removed from the sampling line.

NOTE 1.—When using sample bottles as described in Section 23 (a), provide four branches in the outlet from the sample cooler and collect the several samples simultaneously, as described in Section 25 (a). When removing the individual samples, do not interrupt the flow through the remaining sample bottles.

(b) *Fixing*.—Fix both the 500-ml. and 250-ml. samples (Note 2) as samples, using 2.0 ml. each of alkaline potassium iodide solution (not iodized), MnSO_4 solution, and H_2SO_4 solution in that order as described in Section 7 (b).

NOTE 2.—When using sample bottles, fix the contents of two bottles with 1.0 ml. each of the three solutions and fix the contents of a third bottle with 2.0 ml. each of the three solutions following the procedure described in Section 25 (b). Retain the contents of the fourth bottle as unfixed sample.

(c) *Titration*.—Drain the contents of the 500-ml. tube (Note 3) into the clean casserole and titrate with 0.005 N $\text{Na}_2\text{S}_2\text{O}_3$, as described in Section 13 (c) (Note 4). Rinse the casserole with distilled water, and drain into it the 250-ml. sample (Note 3). Add to the casserole sufficient unfixed sample, collected as described in Paragraph (a) and measured in a graduated cylinder, to bring the contents to same volume as the contents of the 500-ml. sample tube and then titrate as described for the 500-ml. sample. Titration should be completed within 30 min. of sampling.

NOTE 3.—When using the sample bottles, combine the contents of the first two bottles (those fixed with 1 ml. of each solution) in the casserole and titrate the resulting 600-ml. sample. Similarly, combine the contents of the third bottle (that fixed with 2 ml. of each solution) and the fourth (unfixed) bottle and titrate as the second sample.

NOTE 4.—If the blue color of starch iodide does not develop when starch is added to one or both samples, discard both samples. To subsequent samples add an equal, small amount of iodine solution (Section 18 (b)), measuring to an accuracy of plus or minus 0.01 ml. by use of a pipette (Section 5 (h)). Carefully clean the pipette after using.

Calculation:

20. Calculate the dissolved oxygen content of the sample, in terms of parts per million, as follows:

$$\text{Dissolved oxygen, ppm.} = \frac{8000n(S_1 - S_2)}{v_1 - v_2}$$

where:

- n = normality of the $\text{Na}_2\text{S}_2\text{O}_3$ solution (nominally 0.005),
 S = milliliters of $\text{Na}_2\text{S}_2\text{O}_3$ solution required for titration of the sample (Note), and
 v = fixed volume of sample in milliliters (Note).

NOTE.—Subscripts 1 and 2 refer to the larger and smaller samples, respectively.

Precision and Accuracy:

21. Where this method is applicable, an experienced analyst can obtain results with a precision of 0.004 ppm. and with an accuracy of 0.007 ppm. or 1 per cent, whichever is the greater.

NON-REFEREE METHOD C

Application:

22. This method is applicable to the determination of dissolved oxygen in concentrations greater than 0.1 ppm., when high precision is not required. It is useful where rapid results are desired and is not suitable for the analysis of contaminated waters.

Apparatus:

23. The apparatus shall consist of the following:

(a) *Sample Bottle*.—One 300-ml. B.O.D. bottle having a raised lip around the neck and a glass stopper ground to a conical lower tip. The capacity of the bottle must be measured to the nearest milliliter and the stopper should be tied to the neck of the bottle with a loop of cord.

NOTE.—A single sample tube (Section 5 (a)) is at least equally as satisfactory as the bottle.

(b) *Pipettes and Casserole*.—Three 2-ml. transfer pipettes, a casserole (Section 11 (a)), and serological pipettes (Section 5 (h)).

Reagents:

24. For descriptions of the reagents required, see Section 6 (a), (d) to (f), and (h).

Procedure:

25. (a) *Sampling*.—Collect the sample as described in Section 13 (a). Connect the source of the sample to a length of glass tubing slightly longer than the depth of the bottle. Put the glass tubing into the bottle and allow the bottle to fill and overflow, with the water entering at the bottom, until there have been at least ten changes of the contents. Wet the stopper and then slowly withdraw the glass tube while sample continues to flow through it. As soon as the tip of the tube clears the liquid surface, ease the stopper into the neck and let it float down into its seat. Twist the stopper in tight, invert the bottle, and inspect for air bubbles. If any can be seen, discard the sample and collect another.

(b) *Fixing*.—Fill a 2-ml. transfer pipette with alkaline potassium iodide solution (not iodized), and with the pipette filled to the tip so that no bubble of air will be forced into the sample, ease the bottle stopper out of its seat and simultaneously thrust the pipette tip past it and into the neck of the bottle. Allow the contents of the pipette to drain into the bottle and, as the level in the pipette approaches that in

the bottle, raise the pipette out of the bottle and let the stopper fall back into its seat. Fill another 2-ml. pipette with MnSO_4 solution and add this to the sample in the same way. Seat the stopper tight, and shake or rotate the bottle to mix the contents thoroughly. Allow the bottle to stand and, when the precipitate has settled below the shoulder of the bottle, add 2 ml. of H_2SO_4 solution in the same way. Stopper and shake until all precipitate is dissolved. Fixing should be completed within 15 min. after sampling.

(c) *Titration*.—Empty the cup around the stopper of the bottle and wash it with distilled water. If the temperature of the sample is above 70 F., cool it by immersing the bottle in a bath of cracked ice. Remove the stopper, drain the contents of the bottle into the casserole, and titrate with 0.05 N $\text{Na}_2\text{S}_2\text{O}_3$ as described in Section 13 (c). Titration should be completed within 30 min. after sampling.

Calculation:

26. Calculate the dissolved oxygen content of the sample, in terms of parts per million, as follows:

$$\text{Dissolved oxygen, ppm.} = \frac{8000nS}{v}$$

where:

- n = normality of the $\text{Na}_2\text{S}_2\text{O}_3$ solution (nominally 0.05),
 S = milliliters of $\text{Na}_2\text{S}_2\text{O}_3$ solution required for titration, and
 v = milliliters of sample.

Precision and Accuracy:

27. Where this method is applicable, an experienced analyst can obtain results with a precision of 0.03 ppm. and within 0.05 ppm. of the true values.

The pH of Some Standard Buffer Solutions from 0 to 60 C. and the Calibration of Glass Electrode pH Meters¹

By George G. Manov² and S. F. Acree²

ABOUT half a century ago, the attention of chemists was drawn to the observation that the aqueous extracts of various plant and animal substances such as lichens, red cabbages, and cochineal bugs gave changes in color with certain acids and bases, but not with others. By using such "indicators" as crude measuring devices in the study of a large number of acids and bases at the same total

concentration, it was found possible to arrange these compounds in the order of their relative hydrogen-ion concentrations. The important concept of the *active* acidity of a solution as compared to the *total* acidity was thus established. In 1909 Sørensen³ introduced the term "pH" to describe the active acidity of a solution.

Thanks to the pioneer efforts of numerous workers, many present-

day chemists use adjusted indicators and a spectrophotometer to measure colorimetrically the pH of a test solution. Perhaps an even larger number use the glass-electrode pH meter. These instruments must be calibrated in terms of known buffer standards. Recognizing the growing importance of pH measurements, the National Bureau of Standards a few years ago began a systematic investigation⁴ of the

¹Presented at the Forty-seventh Annual Meeting of the American Society for Testing Materials, New York, N. Y., June 26 to 30, 1944.

²Associate Physical Chemist and Chief, respectively, pH Standards Section, National Bureau of Standards, Washington, D. C.

³S. P. L. Sørensen, "Études enzymatiques. II. Sur la Mesure et l'Importance de la Concentration des Ions Hydrogène dans les Réactions Enzymatiques," *Compt. Rend., Lab. Carlsberg*, Vol. 8, p. 1 (1909).

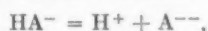
⁴An outline of this program was presented before the Society in a paper by B. Wingfield, W. H. Goss, W. J. Hamer, and S. F. Acree, "The Need for pH Standards," *ASTM BULLETIN*, No. 90, January 15, 1938, p. 15.

acidic and basic properties of buffer salts and indicators over a wide range of temperatures in aqueous and nonaqueous solvents by electromotive force, conductometric, and spectrophotometric methods. The main objective of this study is the production and the certification of solid buffer and indicator standards of requisite purity and stability from which solutions with a precision of 0.002 in pH can be prepared. This precision is much higher than that required by the average laboratory worker.

STANDARD pH VALUES

The method used at the Bureau for the standardization of pH values is based on measurements of the sum of the potentials of hydrogen and silver-silver chloride electrodes immersed in a solution of a buffer containing a known amount of sodium or potassium chloride.⁵ The potential at the silver-silver chloride electrode depends upon the activity of the chloride ion in the solution, and the potential at the hydrogen electrode depends upon the activity of the hydrogen ion which in turn is expressed as the pH of the buffer.

There are several equations which are helpful in visualizing the method of treating the experimental data. The second ionization process for a dibasic acid, for example,



can be represented by the equation:

$$K = (a_{\text{H}^+})(m_{\text{A}^{--}})(f_{\text{A}^{--}})/(m_{\text{HA}^-})(f_{\text{HA}^-}) \quad (1)$$

where the subscripts represent the various ionic species and a , m , and f designate the activity, the molality, and the activity coefficient, respectively, of an ion. The electromotive force, E , between the hydrogen and the silver-silver chloride electrodes is given by the equation

$$E = E^\circ + k(\text{pH}) - k \log a_{\text{Cl}^-} \quad (2)$$

where E° is the normal potential⁶ of the silver-silver chloride electrode and k is the value of the constant, $2.3026RT/F$, at the temperature of the measurements. By

⁵ W. J. Hamer and S. F. Acree, "Potentiometric Method for the Accurate Measurement of Hydrogen-ion Activity," *Journal of Research, Nat. Bureau Standards*, Vol. 23, p. 647 (1939). (RP 1261.)

⁶ H. S. Harned and R. W. Ehlers, "The Thermodynamics of Aqueous Hydrochloric Acid Solutions from Electromotive Force Measurements," *Journal, Am. Chemical Soc.*, Vol. 55, p. 2179 (1933).

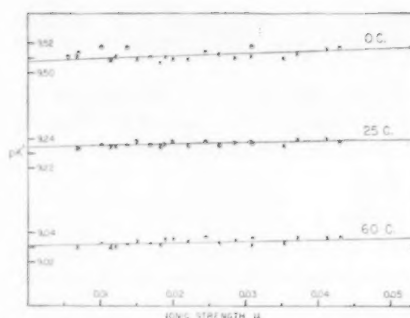


Fig. 1.—Plot of pK' , the negative logarithm of the apparent ionization constant of boric acid in equimolar mixtures of boric acid, sodium borate, and sodium chloride, against the ionic strength for temperatures of 0, 25, and 60 C.

taking the common logarithm of both sides of Eq. 1, defining $\text{pK} = -\log K$ and $\text{pH} = -\log a_{\text{H}^+}$, and combining the result with Eq. 2, one obtains

$$\text{pK} = (E - E^\circ)/k + \log m_{\text{Cl}^-} + \log (m_{\text{HA}^-}/m_{\text{A}^{--}}) + \log (f_{\text{Cl}^-}f_{\text{HA}^-}/f_{\text{A}^{--}}) \quad (3)$$

The right-hand member of Eq. 3 contains only one group of unknown quantities, the term involving the ratio of the activity coefficients of the ions. At finite concentrations of buffer and chloride one may calculate the value of pK' , which is identical with pK except for the omission of the term involving the ratio of the activity coefficients. At infinite dilution, the activity coefficients of all ions become equal to unity, and for this reason $\text{pK}' = \text{pK}$ at zero concentration. One may, therefore, plot the value of pK' against a convenient function of the concentration⁷ and extrapolate the curve to the zero axis to obtain pK . As the cells are usually run in groups of ten and the measurements are made at 5 C. intervals from 0 to 60 C., a sufficiently large number of points is available for an accurate evaluation of pK at each temperature. The data are illustrated in Fig. 1 for borax buffer.

The calculation of the pH of these solutions, however, involves the concept of the activity coefficient of individual ions. As the experimental measurements yield only the mean activity coefficient of hydrogen and chloride ions, the use of some additional assumption is

⁷ The function usually chosen is the "ionic strength," $\mu = \frac{1}{2} \sum m_i z_i^2$, where m_i is the molality of each ion and z_i is its valence. For a detailed discussion of the term ionic strength, see G. N. Lewis and M. Randall, "Thermodynamics and the Free Energy of Chemical Substances," McGraw-Hill Book Co., Inc., New York, N. Y. (1923).

necessary to compute the activity of the hydrogen ion. The Debye-Hückel equation,⁸ widely used to compute ionic activities, involves two constants, A and B , and two parameters, a_i and β . A and B are functions of the dielectric constant of the medium, the charge on the electron, Planck's and Boltzmann's constants, and are independent of the nature of the solution, while the numerical values for a_i and β depend on the nature of the ions in the solution. The first of these parameters, a_i , is the so-called "distance of closest approach" of ions of unlike charge and constitutes the major correction for the departure of the ions from an ideal behavior; the second parameter, β , is essentially a second-order correction term. The evaluation of these parameters is done most conveniently at the time the extrapolation is made for the determination of pK . The details of this procedure and its applications to the calculation of the pH values for malonate and phosphate buffers are given in various publications of this Bureau.^{9, 10}

The pH values for the solutions are then obtained from the measured emf. and the known molality of the chloride ion, the ionic strength, and parameters a_i and β according to the equation

$$\text{pH} = (E - E^\circ)/k + \log m_{\text{Cl}^-} - A\mu^{1/2}/(1 + Ba_i\mu^{1/2}) + \beta\mu \quad (4)$$

For most purposes it is desirable to know the pH value of a buffer solution in the absence of added salts (such as sodium or potassium chloride). By maintaining the concentration of buffer at any constant value (for example, at 0.01 m) while successively diminishing that of the chloride, it is possible to obtain by extrapolation the pH value of a buffer in the absence of sodium chloride. The experimental data presented in Fig. 2 show the effect of sodium chloride on the pH value

⁸ P. Debye, "Kinetische Theorie des Gesetzes des osmotischen Drucks bei starken Elektrolyten," *Physikalische Z.*, Vol. 24, p. 334 (1923); E. Hückel, "Zur Theorie Konzentrierter Wasseriger Lösungen Starker Elektrolyte," *ibid.*, Vol. 26, p. 93 (1925).

⁹ W. J. Hamer, J. O. Burton, and S. F. Acree, "Second Ionization Constant and Related Thermodynamic Quantities for Malonic Acid from 0 to 60 C.," *Journal of Research, Nat. Bureau Standards*, Vol. 24, p. 269 (1940). (RP 1284.)

¹⁰ R. G. Bates and S. F. Acree, "pH Values of Certain Phosphate Chloride Mixtures and the Second Dissociation Constant of Phosphoric Acid from 0 to 60 C.," *ibid.*, Vol. 30, p. 129 (1943). (RP 1524); R. G. Bates and S. F. Acree, "pH of Aqueous Mixtures of Potassium Dihydrogen Phosphate and Disodium Hydrogen Phosphate from 0 to 60 C.," *ibid.*, Vol. 34, p. 373 (1945). (RP 1648.)

of 0.01 m borax buffer from 0 to 60 C.

In this manner, the pH has been determined for a number of buffer mixtures: hydrochloric acid (pH 1),¹¹ hydrochloric acid with sodium chloride (pH 2),¹¹ phosphates (pH 2),¹² phthalate (pH 4),¹³ malonate (pH 5),⁹ phosphates (pH 7),¹⁰ phenol-sulfonate (pH 8),¹⁴ borax (pH 9),¹⁵ and calcium hydroxide (pH 12).¹¹

PRECISION AND ACCURACY OF STANDARD pH VALUES

To chemists familiar with the determination of pH by the hydrogen-calomel or the glass-calomel cell, the method presented above may appear to be quite involved. It should be emphasized that this procedure is necessary to eliminate the uncertainty attached to every pH "determination" by cells involving liquid junctions.⁶¹ These uncertainties may amount to ± 0.05 pH unit, and obviously cannot be tolerated in the establishment of standard pH values.

The precision, or the reproducibility, of the measurements of pK or pH depends upon how closely the solutions can be made up from one time to the next, the variations in the temperature of the thermostat, etc. The accuracy of the determination depends, in addition, upon the uncertainty in the values for E° , k , and other factors, and on the assumption that the activity coefficient of the hydrogen ion is equal to the mean activity coefficient of the hydrogen and chloride ions in the solution. It should be

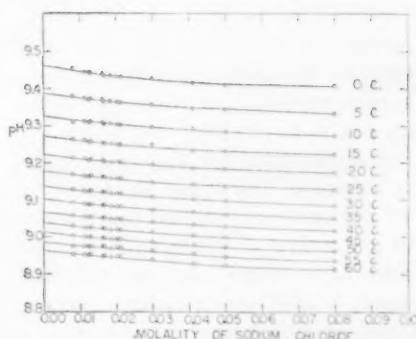


Fig. 2.—Curves showing the effect of sodium chloride on the pH of 0.01 m borax buffer from 0 to 60 C.

noted that the accuracy in the calculation for pK is somewhat greater than that for pH, as the values for A , B , a , and β are not involved. The difference, however, is less than 0.001 unit. The magnitude of the various sources of uncertainties are given in Table I. For purposes of illustration a 0.1 m phosphate buffer at 25 C. has been selected.

Examination of Table I shows that the average reproducibility in pH is approximately ± 0.001 unit at 25 C. While this value changes only slightly with total concentra-

tion of the buffer, the difficulties in the control of the temperature in the neighborhood of 0 C. and the drifts in the emf. of the cells near 60 C. cause the uncertainty to rise to ± 0.003 unit at these temperatures.

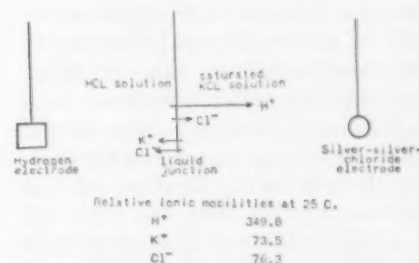


Fig. 3.—The origin of liquid-junction potentials for a typical electrolyte, hydrochloric acid, in contact with saturated potassium chloride, and the relative mobilities of the ions involved in the diffusion process.

TABLE I.—UNCERTAINTIES IN THE DETERMINATION OF pK AND pH BY THE METHOD OF CELLS WITHOUT LIQUID JUNCTION.

Source	Approximate Value	Precision or Accuracy of Measurement ^a	Uncertainty in pK or pH	
			pK	pH
E°	700 mv.	0.05 mv.	0.0008	0.0008
E°	222 mv.	0.05 mv.	0.0008	0.0008
$2.3026RT/F$	59.14 mv./pH	0.011 per cent	0.0007	0.0007
t	25 C.	0.02 C.	0.0002	0.0002
m_{Cl^-} , m_{H^+} , m_{A^-}	0.1 m	0.03 per cent	0.0003	0.0003
A	0.5085	0.16 per cent	...	0.0002
B	0.3281	0.06 per cent	...	0.0001
a	4.4	0.1 A	...	0.0008
β	0.1	5 per cent	...	0.0005
Combined uncertainties:				
in precision			± 0.001	± 0.001
in accuracy			± 0.002	± 0.002

^a For the distinction between the precision and the accuracy of a measurement see text.

tion of the buffer, the difficulties in the control of the temperature in the neighborhood of 0 C. and the drifts in the emf. of the cells near 60 C. cause the uncertainty to rise to ± 0.003 unit at these temperatures.

LIQUID-JUNCTION POTENTIALS

These standards could be used directly for the accurate calibration of pH meters using a calomel half cell and a glass or hydrogen electrode 'were it not for the variable potential generated at the interface between the buffer (or test) solution and the saturated potassium chloride of the reference electrode. For work more accurate than ± 0.05 pH unit, these potentials cannot be

charge. On the other hand, if the solution in the left-hand compartment is alkaline, the fast-moving hydroxide ion tends to make the right-hand boundary negative in sign. It is thus possible to have values for the liquid-junction potential which are either positive or negative. A number of methods of diminishing this potential have been suggested, among which is the use of isoelectric solutions for the reference electrode.¹⁷

¹⁷ C. N. Murray and S. F. Acree, "The Use of Saturated Ammonium Chloride in the Elimination of Contact Potentials," *Journal of Research, Nat. Bureau Standards*, Vol. 7, p. 713 (1931). (RP 369); G. G. Manov, N. J. DeLollis, and S. F. Acree, "Liquid-Junction Potentials, and Relative Activity Coefficients of Chloride Ions, in Concentrated Mixed Chlorides and Nitrates at 25 C.," *Ibid.*, Vol. 33, p. 273 (1944). (RP 1608.)

¹¹ G. G. Manov, N. J. DeLollis, and S. F. Acree, "Comparative Liquid-Junction Potentials of Some pH Buffer Standards and the Calibration of pH Meters," *Journal of Research, Nat. Bureau Standards*, Vol. 34, 115 (1945). (RP 1632.)

¹² R. G. Bates, W. J. Hamer, G. G. Manov, and S. F. Acree, "Provisional pH Values for Certain Standard Buffer Solutions," *ibid.*, Vol. 29, p. 183 (1942). (RP 1495.)

¹³ W. J. Hamer and S. F. Acree, "A Method for the Determination of the pH of 0.05-Molal Solutions of Acid Potassium Phthalate With or Without Potassium Chloride," *ibid.*, Vol. 32, p. 215 (1944). (RP 1586.)

¹⁴ R. G. Bates, G. L. Siegel, and S. F. Acree, "The Second Dissociation Constant of *p*-Phenolsulfonic Acid and pH Values of Phenolsulfonate-chloride Buffers from 0 to 60 C.," *ibid.*, Vol. 31, p. 205 (1943). (RP 1559); R. G. Bates and S. F. Acree, "The Effect of Sodium Chloride on the pH of *p*-Phenolsulfonate Buffers from 0 to 60 C.," *ibid.*, Vol. 32, p. 131 (1944). (RP 1580.)

¹⁵ G. G. Manov, N. J. DeLollis, and S. F. Acree, "Ionization Constant of Boric Acid and the pH of Certain Borax-Chloride Buffer Solutions from 0 to 60 C.," *Ibid.*, Vol. 33, p. 287 (1944). (RP 1609.)

¹⁶ This procedure has been called the method of cells without liquid junction. Actually there is a liquid-junction potential at the interface of the buffer solution saturated with silver and silver chloride surrounding the silver-silver chloride electrode and the buffer solution alone that surrounds the hydrogen electrode. Because of the very slight solubility of silver and of silver chloride, however, this potential is negligible.

Fortunately, it is the difference in the values for the liquid-junction potentials of various buffers in contact with saturated potassium chloride that is important in the calibration of pH meters, and measurements of these differences at 25 C. have been made for a number of buffer mixtures.¹¹

CALIBRATION OF pH METERS

One might judge that, given a standard buffer solution, the determination of the pH of an unknown would be a simple matter and that it would be equally easy for a number of collaborators to agree on the pH value for identical portions of an "unknown" or an "extract." Actually, as the participants in a collaborative determination of pH know, this is far from being the case. In the statistical analysis of the tabulated pH values, the standard deviations obtained include not only the reproducibility attainable by each worker, but also the errors caused by partially defective meters, old electrodes, thermal and electrical hysteresis of electrodes, liquid-junction potentials, or by the contamination of the buffer solutions with carbon dioxide.

It is common practice to calibrate the meter at only one point on the scale by means of a standard buffer such as phthalate or phosphate, for example, and to assume thenceforth that the instrument has been placed in operating condition. This simple procedure can introduce serious errors. The emf. - pH relationship for a glass electrode departs from linearity at the two ends of the scale and yields an S-shaped curve, an old electrode may continue to give a linear calibration in the pH range of 2 to 9, but the slope of the line may be somewhat in error, and cracked electrodes usually give an apparent reading that is almost independent of the pH of the solution but which can be made to agree with the pH value of the standardizing buffer by a sufficient movement of the "asymmetry potential" or the "zero control" knob. In such cases, the use of "standard emf. - pH tables" (such as are frequently used in connection with the student type of potentiometer and quinhydrone electrodes) can then lead to large errors. Several cases have been ob-

served in which the precautions listed by the manufacturer had been ignored and quinhydrone allowed to dry out or to oxidize. For example, the quinhydrone in the open compartment of the glass electrode in one pH meter which had been in use for a number of years had changed from the equi-molar mixture of quinone and hydroquinone to one assaying almost 85 per cent quinone. This completely nullified the use of the tables and resulted in apparent pH values which were all high by 0.5 unit.

The practical method for diminishing these sources of error is to calibrate the instrument with two or more standard buffers; in most cases the additional effort required is but a small part of the total. For meters of the glass electrode type, it is suggested that potassium acid phthalate and borax be used; for those using hydrogen electrodes, on the other hand, it is suggested that phosphate and borax buffers be used, as the phthalate tends to be reduced to hexahydrophthalate ion rapidly by platinized and slowly by palladinized electrodes.¹⁸

It should be borne in mind that performance of the meter itself should be differentiated from that of the electrodes, and that calibrations of each should be made. The completeness of the tests naturally depends on the facilities available. There is, however, a simple test that can be performed by the user. The

¹⁸ W. J. Hamer and S. F. Acree, "Comparison of Platinum and Palladium-Hydrogen Electrodes in Aqueous Solutions of Acid Potassium Phthalate," *Journal of Research, Nat. Bureau Standards*, Vol. 33, p. 87 (1944). (RP 1598.)

glass and calomel electrodes should be removed and the corresponding terminals on the meter short-circuited by means of a wire. If the dial is graduated in millivolts and the meter is set to measure "emf.," a balance should be obtained at the zero reading of the scale. Where the meter is calibrated only in terms of pH, the dial should be set either to pH 4 or to pH 7 (or the appropriate value depending on the electrode system used). It should be possible to bring the instrument to balance by rotating the "asymmetry potential" or the "zero control" knob. More elaborate tests, best performed at the factory, consist in the calibration of the scale of the instrument, and in checking the standard cell and resistors. The performance of the glass electrode itself should be measured with buffer standards of known pH.

Tests were made on a number of calibrated commercial pH meters of industrial and laboratory types at the Bureau with Corning Type 015 and the "low sodium-error" glass electrodes. A portion of the results, published in detail elsewhere,¹¹ are given in Table II for the Type 015 electrode. The pH values for temperatures and concentrations other than those given in Table II can be obtained from previous publications of the Bureau.^{9,10,12,13,14,15} These standards are recommended for checking glass electrodes. In the analysis of unknown solutions, it is recommended that a standardizing buffer be selected that most nearly approximates the unknown in pH and in composition.

TABLE II.—AVERAGE PERFORMANCE OF TYPE 015 GLASS ELECTRODES IN VARIOUS BUFFERS AT 25 C.

Buffer ^a	pH _{true}	pH _{obs}	Correction for Liquid-Junction Potential	Correction for Alkali Error	pH _{obs} (corr)	pH _{true} - pH _{obs} (corr)
Phthalate.....	4.008	(4.01) ^b	0.00	0.00	4.01	(0.00)
Hydrochloric acid.....	1.081	1.09	-0.01	0.00	1.08	0.00
Hydrochloric acid and chloride.....	2.101	2.08	0.02	0.00	2.10	0.00
Phthalate and chloride.....	3.989	3.99	0.00	0.00	3.99	0.00
Phosphate and chloride.....	6.863	6.86	0.01	0.00	6.87	-0.01
Phenolsulfonate and chloride.....	8.795	8.77	0.02	0.00	8.79	0.01
Borax and chloride.....	9.135	9.14	0.00	0.02	9.16	0.01
Calcium hydroxide and chloride.....	12.38 ^c	12.15	0.03	0.20 ^d	12.38	(0.00)
						Av. ±0.01

^a Composition of the buffer solutions in moles per liter of solution:

0.05 m KHC₈H₄O₄
 0.1018 m HCl
 0.01 m HCl + 0.09 m NaCl
 0.05 m KHC₈H₄O₄ + 0.02 m KCl
 0.02 m KH₂PO₄ + 0.02 m Na₂HPO₄ + 0.02 m NaCl
 0.02 m KHPs + 0.02 m KNaPs + 0.02 m NaCl; Ps = paraphenolatesulfonate ion
 0.02 m H₂BO₃ + 0.02 m NaBO₂ + 0.02 m NaCl
 0.01727 m Ca(OH)₂ + 0.01819 m NaCl

^b The meter was set to read this value by the use of the asymmetry potential knob.

^c Preliminary value ±0.02 pH unit.

^d Obtained by difference.

Surface-Conversion Coatings

By George W. Jernstedt¹

SURFACE-conversion coatings are formed by chemical modifications of metallic surfaces in order to secure greater resistance to high humidity, corrosive atmosphere, or high temperature.

In most cases the resultant finish is an oxide or at least an oxidation product. Conversion coatings are produced either by an impressed potential or by a chemical dipping process, they are in widespread use and are employed on all of the more generally used base metals. In order for a conversion coating to have commercial application, it must fill the following four conditions:

1. Ease of application and control in production.
2. Salable appearance.
3. Sufficient corrosion resistance for the intended applications.
4. Satisfactory physical properties such as abrasion resistance and adhesion.

Most of the processes that are in large commercial use today are covered by patents or are proprietary processes. The subject will be covered under the following general topics: base metals involved, basic conversion coating, type of solution, characteristics including appearance and thickness, corrosion resistance, production processes, and variations in finishing. In order to secure some basis for comparison of corrosion ratings, the values of salt-fog corrosion resistance are based on the standard 35 C., 20 per cent sodium chloride salt fog.

Conversion coatings are almost always rather brittle and in general cannot be satisfactorily drawn or shaped without fracturing or making porous the protective film. There are several methods of getting around this shortcoming. One is to supplement the conversion coating with an oil dip which fills in the pores and thus enables it to withstand forming operations. It is also

possible to apply a final sealing operation after the shaping operations.

Most conversion coatings form a good base for lacquer or paint adhesion and much of the processing of this type of coating is followed by some kind of organic finish such as lacquer, oil, wax, or the like.

IRON AND STEEL

Within the past five years, the use of phosphating in industry has increased more than a hundred times. The processing of iron and steel with phosphoric solutions has been recorded as far back as the third century A.D. by the Romans. The first written modern evidence of the use of phosphoric acid on steel was observed and reported in 1869. The first patents were issued to Coslett in 1908 and covered a solution of phosphoric acid and ferrous sulfate in definite proportions. A few years later Coslett added zinc sulfate to the bath and obtained better results. In 1918 the Parker Co. discovered that the character of the coating was improved by the use of the primary manganous phosphate. This led to the process subsequently known as "Parkerizing."

The basic conversion coating has been analyzed many times and is considered to be a ferro-zinc phosphate complex. Today the solutions marketed under the names of "Bonderizing" and "Parkerizing" are essentially compositions containing phosphoric acid, zinc nitrate, ferrous phosphate, and sodium nitrate. The zinc actually enters into the reaction and is found in the crystal structure. The nitrate radical is present only as an accelerator and as such aids in the removal of hydrogen from the surface. The more generally used baths are operated at about 180 F.; however, the new spray processes for automobiles and refrigerators operate at about 125 to 135 F. The phosphate coating is a dark gray matte surface. The crystals are visible under a microscope at about 20 magnifications.

The thickness of the standard phosphate coatings such as Bonderizing run from 0.00005 to 0.0001 in. The thickness of the heavier films such as Parkerizing run from 0.0001 to 0.0003 in. Both finishes give about 4 hr. salt-fog resistance when tested without further treatment. Parkerizing, however, accompanied by an oiling operation can give 25 to 50 hr. salt-spray corrosion resistance and both Bonderizing and Parkerizing can give 100 to 200 hr. salt-spray corrosion resistance when treated with the proper organic finish.

Phosphating has come to be a short-time process. Many of the new developments in this field have been directed to this end. For Bonderizing in strip mills, the time can be as short as 7 sec. and in job shops about 2 min. Parkerizing usually takes 30 min. These finishes are relatively low in cost when compared with equivalent metallic coatings. When phosphate coatings are to be considered for an application, one of the primary considerations should be surface preparation. Acid pickling should be avoided if at all possible.

The blackening and blueing of steel is used a great deal today in our armament program. Gun barrels, gun parts, and gun mounts are often finished with the black ferro-ferrie oxide coating. This process is normally carried out in a concentrated sodium hydroxide - sodium chlorate bath operated between 285 and 290 F. The temperature is controlled by keeping the concentration of the solution such that it boils at this point. If the boiling point rises, the solution is diluted in order to maintain uniform processing. The finish varies all the way from a thin blue surface to a dense smooth black finish. The thickness is usually between 0.00004 and 0.00008 in. The untreated black finish will usually last 2 to 6 hr. in the salt spray, but when oiled it will last 25 to 100 hr. The process con-

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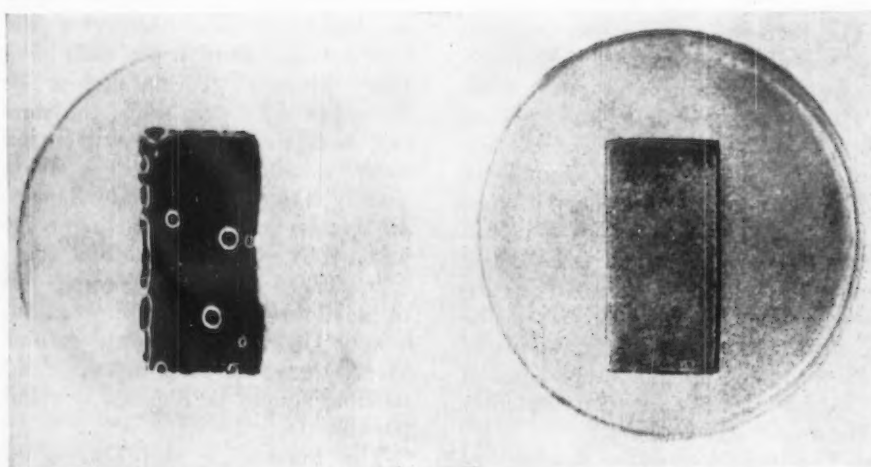


Courtesy of Parker Rust Proof Co.

Plain, untreated steel panel carrying two coats of baked enamel, pricked and subjected to 228 hr. in the salt spray. Light areas show where alkali has destroyed the paint film surrounding rusted abrasion.

Bonderized steel panel with two coats of baked enamel, pricked and subjected to 228 hr. in the salt spray. Slight rust appears where metal was exposed, but no spreading of corrosion or alkali to surrounding area has taken place.

Fig. 1.



Courtesy of Parker Rust Proof Co.

Reproduction of four-color photograph of plain, untreated steel sample tested in agar agar medium. Dark areas indicate dissolving ferrous iron. The dark spotted areas show the development of alkali.

Reproduction of four-color photograph of a Bonderized sample tested in same agar agar medium as left disk. No reaction for dissolving iron or alkali development is apparent.

Fig. 2.

sists of cleaning the steel and then dipping it in the alkaline bath for about 15 min. It is possible to blue steel anodically in a plain sodium hydroxide solution. A number of interesting formulas for blueing steel will be found in National Bureau of Standards Circular² No. 80, Second Edition, 1922, and in *Letter Circular LC 630*, February 1, 1941. These may be obtained from the Superintendent of Documents, Gov-

ernment Printing Office, Washington, D. C.

COPPER AND BRASS

Copper and brass are treated in several different ways to produce a black finish. The cupric oxide finish can be obtained by oxidation in a sodium carbonate-ammonium hydroxide and copper carbonate solution. The finish is blue-black but not too stable to light. It is

particularly applicable to yellow brasses. In general, black finishes of high quality can be secured by use of the proprietary baths of the Enthone Co. called "Ebonol" finishes. The exact composition of these baths is not disclosed, but they produce the same fundamental basic conversion coatings. The copper sulfide finish is produced in a sodium sulfide solution operated at room temperature. This finish is brownish black in appearance. Both the oxide and the sulfide coatings are approximately 0.00005 to 0.0001 in. in thickness. Unlacquered, they will stand up 15 to 20 hr. in the salt spray before the first green salts appear. Lacquered or oiled, they will last 100 to 200 hr., depending upon the type of the organic finish. The oxide type coating is obtained by processing for about 1 min. at 200 to 220 F. To obtain the sulfide finish, the piece is dipped in the sodium sulfide solution for about the same length of time, at room temperature, depending upon the degree of blackness desired. It is detrimental in processing copper and its alloys to allow the material to remain in the solutions too long. This produces heavy, soft, and nonadherent deposits.

ALUMINUM AND MAGNESIUM

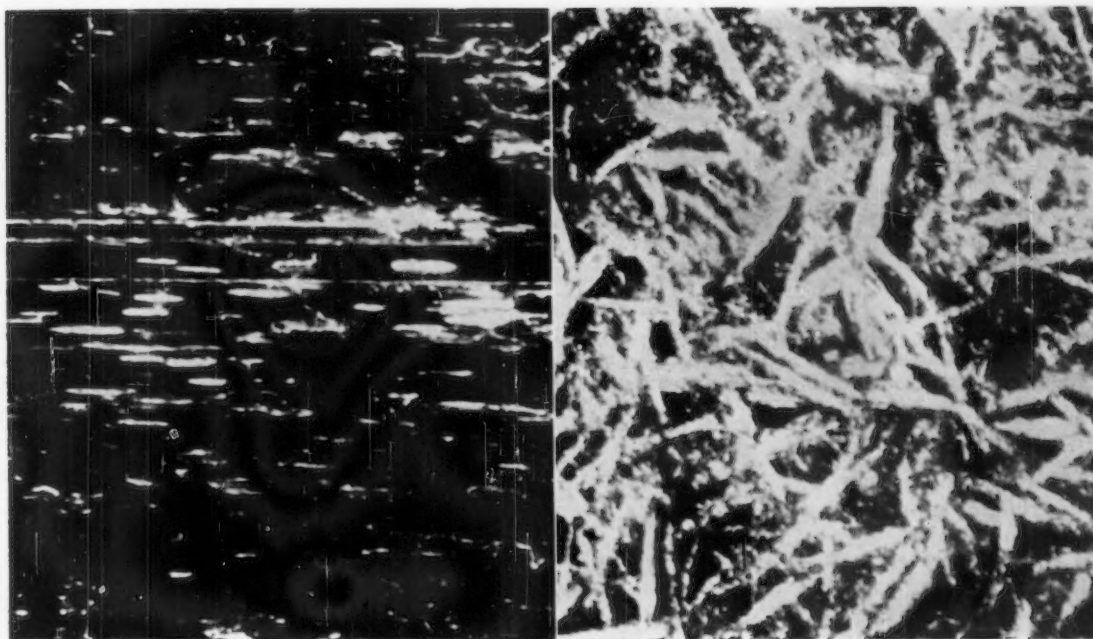
The anodic treatment of aluminum presents problems of scientific as well as of commercial interest.² Of particular interest is the fact that, during the anodic oxidation process, the oxide continues to form at the metal-oxide interface under any oxide previously formed. This has led to speculation as to the mechanism involved in the formation of the relatively thick oxide coatings that are used commercially for decorative or protective purposes. Furthermore, the ability of certain types of oxide coatings to adsorb dyes and other substances has stimulated research to determine the actual structure of these adsorptive coatings.

It has been found that anodic

² J. D. Edwards, "Anodic Coatings on Aluminum," *Transactions, Am. Electroplaters' Soc.*, June, 1939.

J. D. Edwards and F. Keller, "The Structure of Anodic Oxide Coatings," *Transactions, Am. Inst. Mining and Metallurgical Engrs.*, Tech. Pub. No. 1710 (1944).

A complete list of references on anodic and surface-conversion coatings will be found at the end of the article on "Anodic and Surface-Conversion Coatings on Metals," by Edwards, *Transactions, Electrochem. Soc.*, 1942.



Courtesy of Parker Rust Proof Co.

Fig. 3.—Comparison of Plain Black Plate Full Finish Steel and the Same Plate Bonderized.
(X 400)

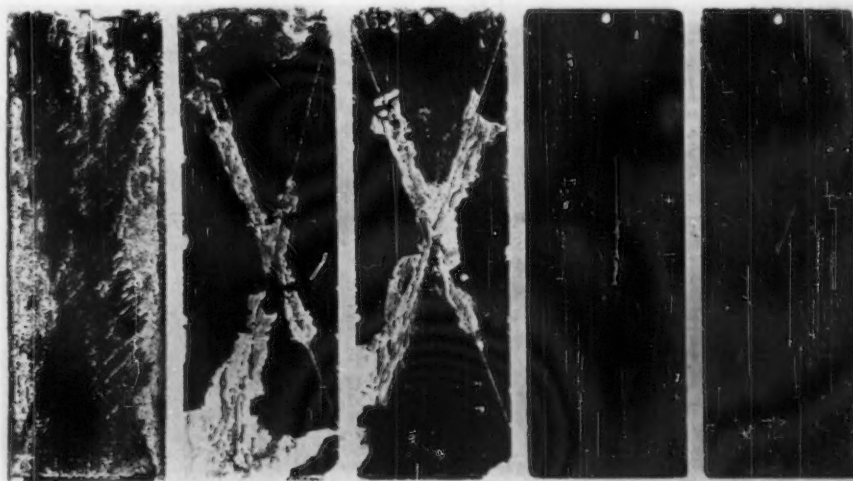
coatings on aluminum are composed essentially of aluminum oxide. They are formed by the action of oxygen ions penetrating to the metal surface during the electrolytic oxidation treatment. These coatings can be formed in a number of different electrolytes, as, for example, those which contain sulfuric acid, chromic acid, oxalic acid, or boric acid. These are the commonest and most useful electrolytes employed commercially. Except for certain specific conditions of formation, the coatings in general have been found to be amorphous alumina, as far as can be determined by X-ray or electron-diffraction methods.

Anodic oxidation processes can be arranged in three rather general classes if they are grouped in relation to the solvent action of the electrolyte on the coating. In the first class, the electrolyte has little or no solvent action on the coating that is formed. In general, coatings produced under such circumstances are nonporous and nonadsorptive. In the second class, the electrolyte exerts an appreciable solvent action on the coating. These coatings are porous and adsorptive. Finally, for the third class, the electrolyte tends to dissolve the coating about as rapidly as it is formed. This action

produces electrolytic brightening or anodic polishing of the aluminum surface and at most leaves only a very thin film of oxide.

The nonporous and nonadsorptive type of oxide film is represented by the coatings that are formed when solutions of boric acid are employed as the electrolyte. It is especially

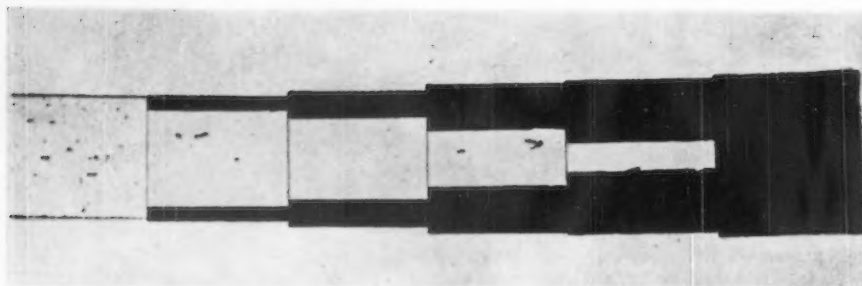
significant that these impervious films are formed in electrolytes that exert little or no solvent action on the coating. Where a boric acid electrolyte is used, the coating tends to form rapidly, with the result that the flow of current is soon reduced substantially. This indicates that the growth of the coating has



Courtesy of Parker Rust Proof Co.

(a) Sand-blasted steel. (b) Alkali cleaned steel. (c) Phosphoric acid-dipped steel. (d) Bonderized steel. (e) Alkali cleaned stainless steel.

Fig. 4.—Comparative Corrosion Resistance of Two Coats of Black Enamel Over Steel.



Courtesy of Aluminum Company of America.

Fig. 5.—Photograph Showing Six Stages (in Cross-Section) in the Electrolytic Oxidation of Aluminum Foil; Untreated Foil at the Left, Completely Oxidized Foil at the Right and Intermediate Stages in Between. (X 500) (Reduced to 2/3 size in reproduction.)

stopped. As a rule, the thickness of the coating is roughly proportional to the voltage employed for formation, and the coatings of this type are exceedingly thin.

The adsorptive type of oxide film has many unique applications. The discovery that adsorptive oxide coatings could be colored with pigments by precipitation within the pores has made possible more durable and, in most cases, really permanent colors. The range of colors, is, however, much more limited than is the case with dyes. When, for example, an oxide coating is first treated with a solution of potassium dichromate so as to adsorb chromate strongly within the pores and the coating is then treated with a solution of lead acetate, insoluble lead chromate is precipitated within the pores of the coating. This both seals the coating and gives it a bright chrome yellow. A jet black is provided by the precipitation of cobalt sulfide and blue by precipitation of Prussian blue within the pores of the coating. Adsorptive oxide coatings can also be impregnated with photosensitive salts and photographs reproduced thereon by exposure to light through a negative followed by the usual developing and printing processes. The corrosion resistance of the conversion coatings on aluminum is normally 100 to 200 hr. in the salt fog before a white corrosion product appears. It is, however, rather difficult to give a corrosion rating on this type of finish unless all the specific details are known.

A voluminous art has accumulated around the oxide coating of aluminum by chemical means. Simply treating aluminum with

into solution, and the coating action is very closely connected with the degree of saturation of the coating solution with the dissolved aluminum. Thus directions are frequently given to "work" the treating solution prior to starting coating operations to insure the proper equilibrium between the solution and the metal to be coated.

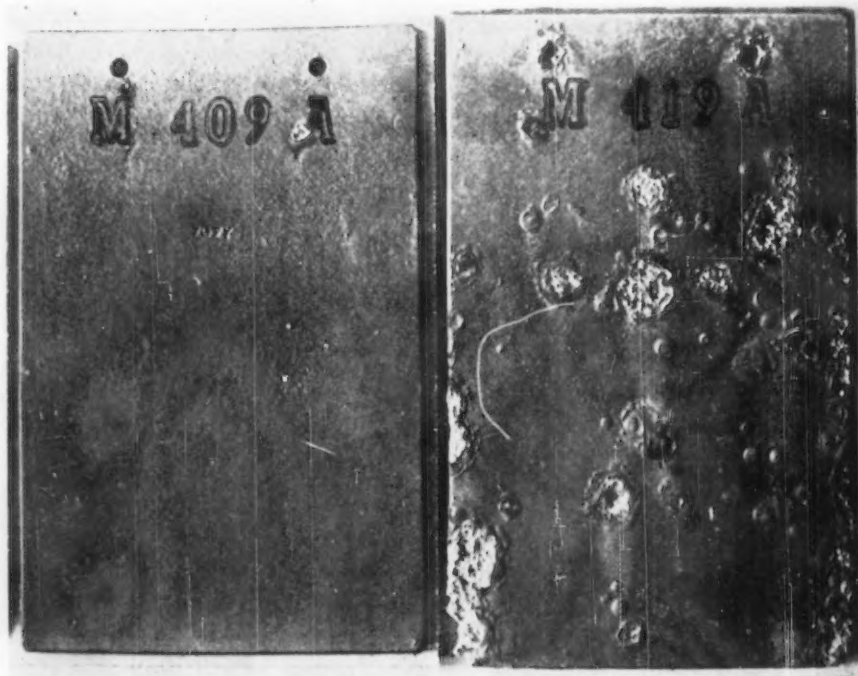
The method which has made an outstanding success in this field is the Alrok method employing a hot solution of sodium carbonate and potassium (or sodium) dichromate.

TABLE I.—TYPICAL PROCEDURES FOR ANODIC OXIDATION OF ALUMINUM.

Electrolyte	Typical Operating Characteristics	Comments
Chromic acid, 3 per cent.....	40 to 50 v., 3 amp. per sq. ft.	Coating gray in tint and usually about 0.0001 in. (0.0025 mm.) thick
Oxalic acid, 3 per cent.....	65 v., 12 amp. per sq. ft.	Coating cream colored; thickness up to about 0.001 in. (0.025 mm.)
Sulfuric acid, 15 per cent.....	15 v., 12 amp. per sq. ft.	Coating white or transparent; thickness up to about 0.001 in. (0.025 mm.)
Boric acid plus ammonium borate..	50 to 500 v.	Coating usually thin and iridescent; thickness proportional to formation voltage

boiling water increases the thickness of the oxide coating normally present. The most successful treatments, however, employ solutions which permit an appreciable but limited attack on the aluminum surface. They usually put aluminum

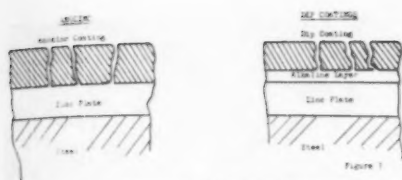
The function of the carbonate appears to be to promote the attack on the aluminum, and the dichromate to inhibit the attack. The action, therefore, depends on a good balance between the concentrations of the two compounds. The ratio of



Courtesy of Aluminum Company of America.

Fig. 6.—Effect of Surface Treatment on Paint Performance on Magnesium.

Satisfactory treatment on left panel, poor treatment on right of AM265 castings alloy; satisfactory paint coating on both panels. Appearance after 6 weeks in alternate immersion tank (synthetic sea water).



Courtesy of United Chromium Corp.

Fig. 7.—Comparison of Electrolytic and Dip Processes of Chromating.

the two must be adjusted to suit the alloy under treatment and the other coating conditions. A commonly used solution employs 2.0 per cent sodium carbonate plus 0.5 per cent potassium dichromate. The coating is usually less than 0.0001 in. thick and of a gray or gray-green color—probably the result of a lower chromium oxide (Cr_2O_3) in the coating. The coating is then sealed, in a 5 per cent boiling solution of potassium dichromate.

Conversion coatings on magnesium are radically different from those produced on aluminum. In the case of magnesium, the oxide and the hydroxide are sparingly soluble in water but the solubility increases some 50 times in water containing carbon dioxide. In the case of aluminum, the oxide is quite insoluble in water or weakly acidic solutions. The anodic treatment of aluminum is more widespread than the anodic treatment of magnesium but a new process for magnesium is that developed at the Consolidated Vultee Aircraft Corp.³ This consists of processing the magnesium in an electrolyte containing caustic soda, sodium silicate, and phenol at about 190 F. for 20 to 35 min. While the coating is thin, it offers good surface protection when used in combination with suitable paint coatings.

The formation of protective coatings on magnesium by chemical

TABLE II.—PROBABLE CHEMICAL REACTIONS IN CHROMATING PROCESSES.

- (a) Chemical
 $3\text{Na}_2\text{Cr}_2\text{O}_7 + 6\text{Zn} + 3\text{H}_2\text{O} = 6\text{Zn}^{++} + 2(\text{CrO})_2\text{CrO}_4 + 6\text{NaOH}$
- (b) Anodic
 $3\text{Zn} + 6\text{F} = 3\text{Zn}^{++} + 6\text{e}$
- (c) Combined (a + b)
 $2\text{Na}_2\text{Cr}_2\text{O}_7 + 9\text{Zn} + 6\text{F} = 9\text{ZnO} + 2(\text{CrO})_2\text{CrO}_4 + 6\text{Na}^+ + 6\text{e}$

treatment has become the almost universal practice where such a coating is needed. In fact, it is routine practice to give most castings and forgings the treatment known as "chrome-pickle" before

³ Marketed by Hanson Van Winkle Munning Co., Matawan, N. J., under name of "Manodyze."

they leave the fabricating plant. A great variety of surface treatments have been proposed but practice is gradually decreasing the number in actual use. It is significant that most of the methods employ chromic acid or chromates as a component of the coating solution or in some step of the process. It is probable that reduced chromium (trivalent) compounds are included in many of these coatings. Certain of these methods are preferred for use on machined surfaces, because

TABLE III.—COMPARATIVE CORROSION RESISTANCE IN SALT SPRAY OF ANOZINC FILMS.

TO FIRST WHITE CORROSION PRODUCTS	
Zinc.....	1 to 2 hr.
Black anozinc (unsealed).....	75 to 125 hr.
Black anozinc (sealed).....	100 to 150 hr.
Yellow anozinc.....	150 to 200 hr.
Transparent anozinc.....	130 to 180 hr.

TO RUSTING OF BASE METAL	
Zinc.....	200 hr.
Black anozinc (unsealed).....	650 hr.
Black anozinc (sealed).....	1000 hr.
Yellow anozinc.....	650 hr.

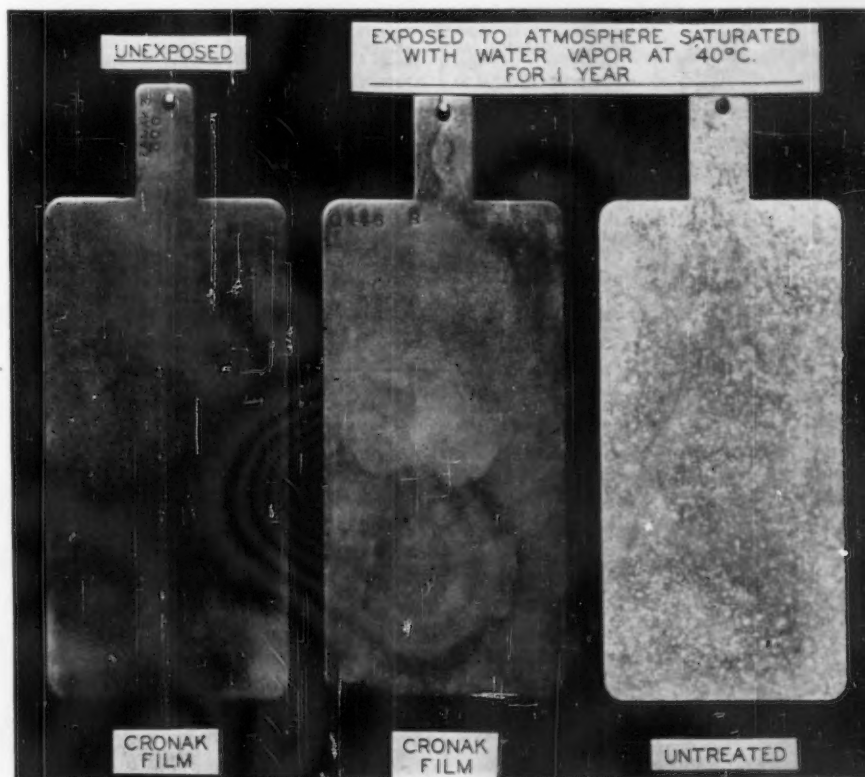
Courtesy of the United Chromium Corp.

they do not remove enough metal to affect seriously the dimensions of the piece.

ZINC AND CADMIUM

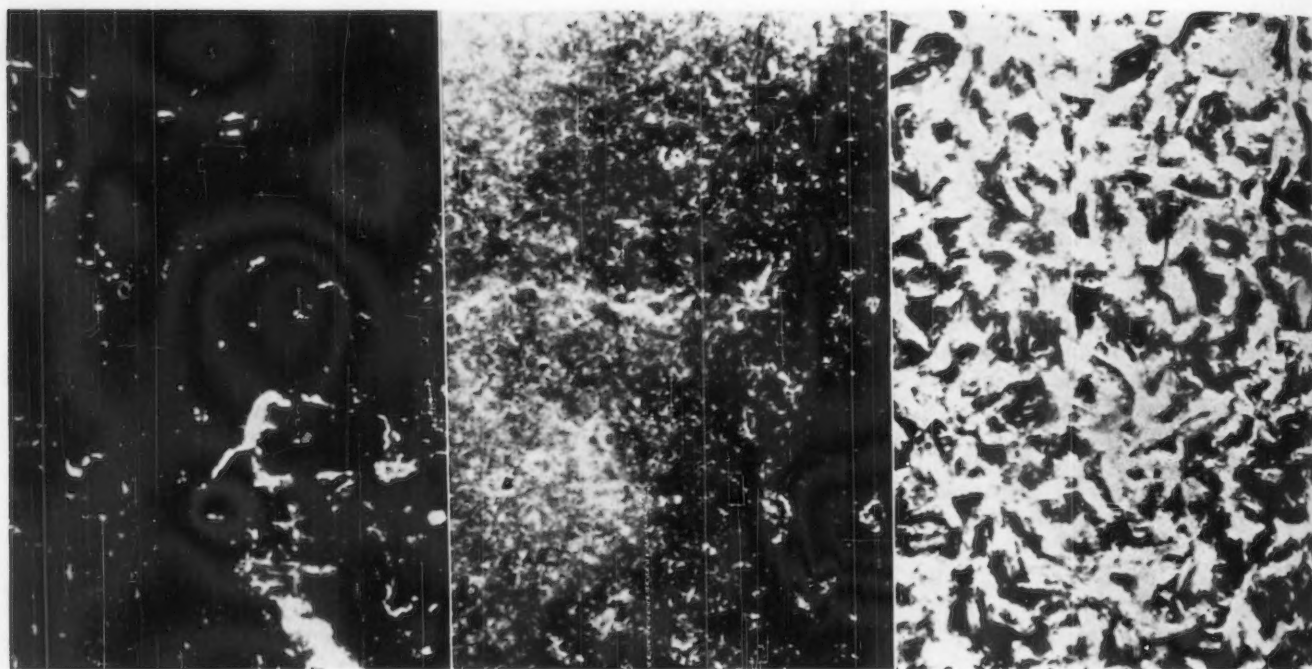
The second world war has brought

into widespread use surface-conversion coatings for zinc, cadmium, and their alloys. This has been mainly for protection against the corrosive effect of tropical atmospheres. Although these metals by themselves give excellent base-metal protection as in the case of zinc or cadmium plating, they give this protection by preferential corrosion at the expense of the plating and the corrosion product is white and voluminous. The chromate finishes on zinc and cadmium give increased resistance against this type of corrosion, even though the process is rather simple and inexpensive. In general, however, chromate finishes of this type are unsatisfactory when subjected to elevated temperatures. Apparently the coatings obtained are a combination of the basic zinc trivalent and hexavalent chromate compounds. The hexavalent is slightly soluble and it has been reported that as little as 0.0001 per cent in solution will prevent corrosion of zinc. The active hexavalent part of the film in the case of the commercial process "Cronak" is approximately 8½ per cent. Many accelerated tests have



Courtesy of New Jersey Zinc Co.

Fig. 8.—Corrosion Resistance of Cronak Films Exposed to an Atmosphere Saturated with Water Vapor at 40 C. for 1 Yr.



(a) (b) (c)
Fig. 9.—Surface on (a) Cold-Rolled Steel, (b), Steel Zinc Plated, and (c) Steel Zinc Plated and Bonderized. (X 400)
Courtesy of Parker Rust Proof Co.

TABLE IV.—CHARACTERISTICS OF SURFACE-CONVERSION COATINGS.

Base	Finish	Basic Conversion Coating and Thickness	Solution Type	Characteristics (Appearance)	Corrosion Resistance in Standard Salt Spray	Process
Iron and steel	Phosphating	Ferro-zinc phosphate complex. Fast (Bonderize) 0.00005 to 0.0001 in. Slow (Parkerize) 0.0001 to 0.0003 in.	Phosphoric acid, zinc nitrate, ferrous phosphate, sodium nitrate. Temperature range, 125 to 180 F.	Dark matte gray crystals visible at 20 X. Promotes adhesion of lacquering	About 4 hr. With organic finishes. Can give 100 to 200 hr.	Can be dipped, sprayed, or brushed. Bonderizing time: 7 sec. to 2 min. Parkerizing, about 30 min. Coating usually oiled or lacquered
	Blueing and blackening	Ferro-ferric oxide, 0.00004 to 0.00008 in.	Sodium hydroxide, sodium chlorate. Temperature range, 285 to 290 F.	Thin, blue - black, smooth finish	Untreated—about 2 to 6 hr. When oiled, can give 25 to 100 hr.	Dipped for about 15 min. Some blueing is done anodically in sodium hydroxide solution. Coating usually oiled or lacquered
Copper and brass	Oxide and sulfide	Cupric oxide or cupric sulfide, 0.00005 to 0.0001 in.	Sodium carbonate, ammonia, hydroxide, copper carbonate, sodium sulfite solution	Blue-black or brown-black. Good base for lacquering	Unlacquered — about 15 to 20 hr., before first green salts. Lacquered or oiled 100 to 200 hr.	Dip process at room temperature for sulfide. Oxide sometimes done at boiling. Coating usually oiled or lacquered
	Oxalate	Copper oxalate compound, 0.00005 to 0.0001 in.	Acid oxalate solution, 150 to 165°F.	Gray matte appearance. Good base for lacquering	With organic coating. Can give over 100 hr.	Dip process 1 to 2 min. Promotes adhesion of lacquer or paint to copper or brass. Increases corrosion resistance.
Aluminum	Anodic	Amorphous Al_2O_3 , generally 0.0001 to 0.001 in.	Chromic, boric, sulfuric, or oxalic acids, usually room temperature	Usually white or gray unless dyed or colored with chromates. Good base for lacquering	Without organic, about 100 hr. before white salts. With organic, over 200 hr.	Anodically at 15 to 60 volts, time depending upon desired thickness—15 to 60 min. Usually sealed or painted
	Chemical	Aluminum phosphate compound. About 0.0001 to 0.0002 in.	Phosphoric acid, and accelerators, 160 to 175 F.	Gray matte appearance. Good base for lacquering	With organic coating. Can give over 100 hr.	Dip or spray process—1 to 5 min.
	Chemical	Al_2O_3 and a hexavalent compound (Cr_2O_3), 0.00005 to 0.0001 in.	Sodium carbonate, and dichromate, about 200 F. plus chromate seal	Yellowish-brown matte surface. Good base for lacquering	Without organic, about 50 hr. Before white salts. With organic, over 200 hr.	Dip process about 15 min. Usually followed by sealing treatment and organic
Magnesium	Anodic and chemical	A magnesium oxide plus a hexavalent chromium salt, 0.00005 to 0.0001 in.	Dichromate, phosphate, sulfate, fluoride. Also, sodium silicate, sodium hydroxide and phenol	Usually yellow or brown. Can be iridescent or gray. Good base for lacquering	Without organic, about 25 hr. to white salts. With organic, over 100 hr.	Anodic process, 5 to 10 amp., 30 to 60 min. Dip process, 2 to 30 min. Both usually followed by organic finish
Zinc	Phosphating and chromating	Zinc-ferro phosphate (Also Ni-Fe). Chromate-tri- and hexavalent chromates, 0.00005 to 0.0001 in.	Phosphating same as steel plus nickel ion 160 F. Chromate-chromic acid plus sulfuric acid. Room temperature	Phosphate — gray matte. Crystalline. Chromates iridescent yellow. Can be almost black	Uncoated, 75 to 100 hr. before white corrosion. With organic, over 200 hr. Uncoated the chromates are recommended. With lacquer the phosphates are recommended	Phosphate dip or spray 15 to 60 sec. Chromate 10 to 20 sec. Chromate generally used as is. Phosphate usually painted. Chromating can be done electrolytically (anodizing)

given unreliable data due to these various unusual conditions. Several methods have been advanced, however, which claim to produce a chromate film which has good corrosion resistance and at the same time is stable to elevated temperatures normally found in paint processing. One of them consists of dipping the standard chromated parts in a 10 per cent solution of sodium dichromate maintained above 200 F. at a pH of 7 to 8. In general, it may be said that, as in the case of aluminum and magnesium, zinc and cadmium do not give similar corrosion resistance from identical conversion processes. Cadmium cannot be processed to give coatings nearly as satisfactory as those on zinc.

The phosphating of zinc and cadmium have come more in the foreground in the past 2 yr. This was primarily for the purpose of securing increased paint adhesion. However, it is now possible to coat zinc in a phosphate solution and secure a relatively nonporous continuous film. The conversion coating in the case of phosphated zinc is either a nickel-zinc phosphate complex or a ferro-zinc phosphate complex. With the exception of the nickel in the nickel phosphating solution, the constituents are the same as those used in the processing of iron and steel.

An unusual phenomenon observed in the treating of metallic surfaces

such as zinc-plated steel with phosphoric acid solutions is known as the "wiping effect."⁴ By mechanically wiping the surface, the structure of the resulting phosphate coating can be greatly refined. Furthermore, the subsequent corrosion resistance of the finished article is decidedly increased. No theories have been published as to the cause of this wiping phenomenon, but it is evident in most phosphating processes. It is very pronounced in the phosphating of zinc-plated surfaces. It has been found that the refinement of the crystalline structure of the surface is not due to any chemical action, but is due to the physical action of wiping the base metal, notably zinc, with a cloth, brush, hand, etc. The cause of this effect is probably the releasing or formation of an adsorbed film on the surface of the metal.

Recently it has been proved possible to refine the crystal structure chemically. This is accomplished by pre-dipping the work in a specially prepared solution of disodium phosphate⁴. The finer-grained coatings make possible the use of one coat of paint where two coats were required to cover up coarser crystal structure.

It is possible to secure 75 hr. salt-fog corrosion resistance with a properly phosphated zinc surface. It is

⁴ G. W. Jernstedt, "New Phosphate Coatings with Unusual Corrosion Resistance," *Transactions, Electrochemical Soc.*, Vol. 83 (1943).

desirable, however, to rinse all phosphated coatings in a hot, dilute, chromic acid solution to improve their resistance to corrosion. When a phosphated zinc surface is coated with an organic finish, the corrosion resistance may easily go beyond 200 hr. in the salt spray. There is a great future for this type of coating. A thin coating of zinc plus phosphating can be applied in the steel mill and may be even a prime coat of organic added at this time. The coating would not be very expensive and would offer considerably superior corrosion-resistant finish for such articles as automobile bodies, refrigerator boxes, etc.

In the over-all picture, surface-conversion coatings are almost always the result of oxidation of one form or another, and generally are relatively thin and nonflexible. This type of coating cannot be drawn or bent without some fracturing of the film. The tendency today is toward the development of finer-grain (smaller crystals for anodizing, phosphating, etc.) finishes for aluminum, magnesium, zinc, and steel so that the base metals may be processed in the strip mill and then formed to the finished part with few or no finishing operations after forming. Today strip steel is being Bonderized for just such applications. In addition, several lines are in operation in the steel mills in which the strip steel is coated with zinc, then phosphated.

Article on Bolting

THE current issue of *Fasteners*, published by the American Institute of Bolt, Nut and Rivet Manufacturers, 1550 Hanna Building, Cleveland 15, Ohio, carries the first of two concise articles covering "Bolting for Pipe Flanges and Pressure Vessels," prepared by Sabin Crocker, Senior Engineer of the Detroit Edison Co., who is an authority in this field and very active in the work of A.S.T.M. Mr. Crocker, in his article makes numerous reference to A.S.T.M. standards, describing the important use of these specifications. There is an interesting table summarizing the chemical composition and physical properties of both carbon and alloy steel bolting materials.

Steadying Influences

"WITH the multiplication and the subdivisions of trades and professions which have been characteristic of our industrial development, relatively small groups of people can now affect the economic welfare of thousands. A few can now cause inconveniences and even actual suffering for many. The present wave of strikes is indicative of the situation.

"In such warnings of a possible national chaos, it is essential that members of certain older professions reevaluate their responsibilities to mankind. It is unthinkable that members of the professions of medicine, of law, of teaching, and of engineering be drawn into this vortex of unrest. All must prove to be steadying influences if our new order is to survive, and if our nation is to prosper in unlimited progress."

—*Journal of the Engineering Societies of New England*, October 22, 1945

Highway Research Board Proceedings

THE 560-page Proceedings of the Highway Research Board's 24th Annual Meeting gives a large number of technical papers, reports, and discussion of interest to those who are concerned with highway problems including economics and finance. Major portions of the Proceedings cover design, with over 100 pages devoted to maintenance and some 160 pages covering soils investigations. The Proceedings, in addition, includes pertinent information on the Board, its member organizations, various departments, contact men, and numerous committee reports. Page size 6½ by 9½ in., tan cloth binding. Available from the Highway Research Board, National Research Council, 2101 Constitution Ave., Washington 25, D. C., at \$5 per copy. (Check should be made payable to the National Academy of Sciences.)



Progress on New Society Headquarters

Permanent Building Fund
Established—Donors Listed

DIRT and dust are literally beginning to fly at 116 Race Street. The contract for alterations and reconstruction of the new headquarters building was let on November 14. Much interior demolition has been completed and foundations for construction of a three-story addition at the rear of the building are being constructed. General plans and specifications are in an advanced stage of preparation, although there are still many important details to be worked out.

The plans give special attention to facilities for members, including a Members Room off the first floor lobby, a Committee Room on the second floor, and a Board Room on

the third floor, which is so arranged that it can be readily divided to accommodate two meetings. These facilities in conjunction with certain offices will permit the holding of some six meetings simultaneously. It is not, of course, possible to provide for an auditorium in the building, but we are fortunate in being located so near to the Franklin Institute, in whose splendid auditorium of 400 capacity have been held so many meetings of the Society.

Particular attention is also being paid to the most efficient arrangement of the Society's office and work space, including facilities for such work-a-day things as the handling of mail, receipt and shipping of publications, and the like. It has been decided to air-condition the building, using the most modern system combining heating and conditioning. There will also be installed a small passenger elevator located in the lobby.

It is planned to reproduce in a future issue of the BULLETIN some of the plans and layout sketches as they are finally developed.

BUILDING FUND

Subscriptions to the Building Fund have now reached the total of

\$144,183 and more are still being received. An alphabetical list of the 497 contributors up to November 30, arranged by companies and individuals, appears below. Supplementary lists of those whose contributions are received after this date will appear in subsequent issues.

While each contribution has been personally acknowledged with the thanks of the Executive Committee, it is desired again to express the sincere appreciation of the President and other officers of the Society for the splendid response that our members have made to this appeal for financing the headquarters project.

It is well that we have exceeded the goal of \$125,000 originally set, for as we had expected in these times the costs of alteration and building construction generally are quite high. As previously announced, such monies as remain after all expenses of establishing the new headquarters have been met will be placed in a permanent Building Fund, to be used solely for capital expenditures on Society headquarters in the future, as distinguished from operating expenses to be met from current income.

There are still quite a few members of the Society who for one reason or another have had to defer decision as to a contribution to the Building Fund. The Executive Committee wishes to remind such members and all others that with the establishment of the permanent Building Fund, contributions from members at any time for this purpose will be most welcome.

COMPANY AND ASSOCIATION SUBSCRIPTIONS TO A.S.T.M. BUILDING FUND UP TO NOVEMBER 30, 1945

The Ajax Metal Co.
Alan Wood Steel Co.
Allegheny Ludlum Steel Corp.
Allied Chemical & Dye Corp.
The Barrett Division
Allis-Chalmers Manufacturing Co.
Alpha Portland Cement Co.
Aluminum Company of America
The American Brass Co. and
Affiliates:
Anaconda Copper Mining Co.
Anaconda Wire & Cable Co.
Andes Copper Mining Co.
Greene Cananea Copper Co.
International Smelting & Refining Co.
Chile Exploration Co.
American Bureau of Shipping
American Can Co.
American Cast Iron Pipe Co.

American Chain and Cable Co.,
Inc., and Divisions
American Chemical Paint Co.
American Creosoting Co.
American Felt Co.
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The American Institute of Archi-
tects
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Division
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For List of Individual
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Danase, L. A.	Heilman, R. H.	Mantz, Victor M.	Silver, Bruce R.	

SUMMARY—From
497 Contributors,
\$144,183

Annual Meeting Papers Requested by February 1

THE Administrative Committee on Papers and Publications again extends its customary invitation to offer papers on subjects relating to properties and tests of engineering materials for presentation at the Annual Meeting and subsequent publication by the Society.

It is important this year that the program of our Annual Meeting be developed at an early date so that members may make their hotel reservations well in advance. Also, in order that as many as possible of the technical papers and committee reports can be preprinted in advance of the meeting, it is desirable that manuscripts for papers be received early.

The Committee on Papers and Publications will hold its next meeting early in February to consider the papers to be published by the Society in 1946 and to develop the program for the Annual Meeting. Therefore, February 1 has been fixed as the limiting date for the receipt of offers.

Offer forms can be obtained from the Society offices. Each offer must be accompanied by a summary of the proposed paper in such detail that its scope is clear and also to point out features that in the

author's opinion make the paper a desirable one for presentation and discussion.

As pointed out in the October ASTM BULLETIN, Technical Papers are preprinted and distributed to the members throughout the year as they become available. In other words, manuscripts that are available early need not be held for printing just prior to the Annual Meeting.

Grants for Postwar Collegiate Research

AN ANNOUNCEMENT from the Research Corporation, 405 Lexington Ave., New York City, of which Dr. Joseph W. Barker, Dean of Engineering, Columbia University, is Acting President, indicates that over \$2,000,000 is available for grants to educational institutions for carrying out scientific research and teaching. The five-year program contemplates grants in the order of \$2500 to \$5000 annually so that scientists who have been engaged largely in war research will be able to devote their energies to work of peacetime importance particularly in the fields of chemistry, physics, mathematics and engineering.

Several leading research directors and educators are associated with Dr. Barker in the corporation which in 1912 was instituted with a gift of patent rights on electrical precipitation. Over \$1,250,000 has been involved in grants made by the corporation to some 52 institutions in recent years.

Further information can be obtained from Dr. Robert R. Williams, Coordinator of Research of the Research Corporation.

Highway Specifications

IN THE July issue of *American Highways*, which is the journal of the American Association of State Highway Officials, 1220 National Press Bldg., Washington 4, D. C., there is information on new and revised A.A.S.H.O. specifications and tests for highway materials. Numerous changes are referred to which are intended to bring the association's standards in line with corresponding A.S.T.M. designations, although there are some exceptions. It is planned to publish the new and revised standards in an addenda to the 1942 edition of the book of standard specifications issued by the Association but in the meantime because of publication delays a complete list of the new and revised standards with titles, A.A.S.H.O. and A.S.T.M. designations, was included in the July journal and for convenience the list included a reference to the appropriate A.S.T.M. books.

Many members of the Association are extremely active in A.S.T.M. technical committee work and the Association is officially represented on numerous A.S.T.M. technical committees.

Many Committees Submit Actions on Standards

New and Revised Specifications and Tests Recommended by Committees on Steel, Copper Wire, Petroleum Products, Thermometers, etc.

FROM the accompanying list of actions on new tentatives, revisions of tentatives and standards, it can be seen that numerous actions have been taken by the Administrative Committee on Standards, on the recommendation of the technical committees responsible.

COMMITTEE A-1 ON STEEL

The several recommendations submitted by Committee A-1 on Steel involve two new tentative specifications for high-strength and mild to medium-strength steel castings, the revision of three tentatives, withdrawal of a previously widely used bolting specification, and the tentative revision of two existing standards, one for copper brazed tubing and the other for nuts for bolts for high-pressure and high-temperature service.

Based on very extensive studies carried out by the Steel Founders Society of America, the new tentatives for steel castings as noted in

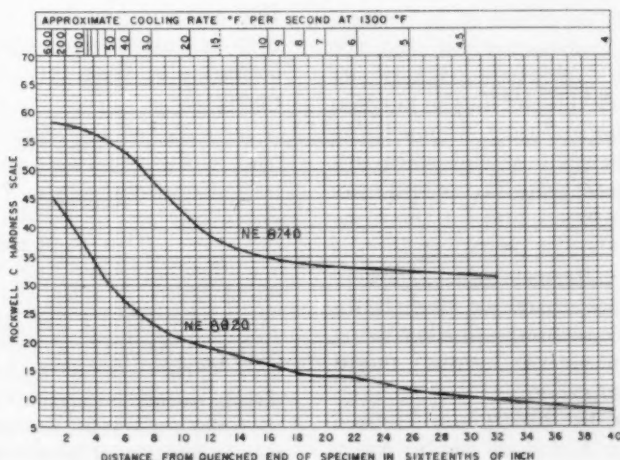
the accompanying table are intended to modernize and consolidate existing A.S.T.M. specifications. The intent is not necessarily to limit the number of grades, but Subcommittee VIII has included changes in the physical and chemical requirements which it is believed are improvements and take advantage of manufacturing advances. Although there was no W.P.B. "L" limitation order covering castings, studies were instituted at the suggestion of the National Emergency Steel Specifications project to simplify grades of castings. These studies carried out by Dr. Briggs (S.F.S.A.) were tabulated, considered, and in part were the basis for the proposals accepted by the committee. A different system of designation is employed, heat treatment terms are simplified and brought up to date, and the changes in physical and chemical requirements are intended to give a rational system of grades.

Because of the widespread use of

A.S.T.M. END QUENCH TEST
FOR HARDENABILITY
OF STEEL (A255-45T)

TYPE	HEAT NO.	GRAN SIZE	C	Mn	P	S	Si	Ni	Cr	Mo	NORM TEMP °F	QUENCH TEMP °F
NE-8740	19237	8-7	.44	.82	.019	.016	.27	.58	.50	.25	1650	1500
NE-8620	621271	7-8	.19	.80	.015	.015	.23	.46	.52	.22	1700	1550

REMARKS:



Facsimile of Hardenability Chart with Two Typical Curves Plotted.

New Tentatives

Specifications for:

Foundry Pig Iron (A 43 - 45 T)
Mild to Medium Strength Carbon-Steel Castings for General Application (A 281 - 45 T)
High-Strength Steel Castings for Structural Purposes (A 232 - 45 T)

TENTATIVE REVISIONS OF STANDARDS

Specifications for:

Carbon- and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service (A 194 - 40)
Copper Brazed Steel Tubing (A 254 - 44)

REVISION OF TENTATIVES

Specifications for:

Seamless Carbon Steel Pipe for High-Temperature Service (A 106 - 45 T)
Alloy-Steel Bolting Materials for High-Temperature Service (A 193 - 45 T)
Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors (B 172 - 45 T)
Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors (B 173 - 45 T)
Bunch-Stranded Copper Conductors for Electrical Conductors (B 174 - 45 T)
A.S.T.M. Thermometers (E 1 - 44)

Methods of:

End-Quench Test for Hardenability of Steel (A 255 - 45 T)

WITHDRAWALS

Specifications for:

Alloy-Steel Bolting Material for High-Temperature Service (A 96 - 44)

Methods of:

EA - D 97 Test for Cloud and Pour Points (D 97 - 39)
EA - D 524 Test for Carbon Residue of Petroleum Products (D 524 - 42)

the current A.S.T.M. specifications A 27 (general), A 87 (railroad), A 148 (structural), and A 215 (welding), the committee is not at this time recommending that they be dropped, but wishes to have the two new specifications published as information, with different serial designation, and if satisfactory they can eventually replace the existing four standards.

In order to consolidate requirements on bolting materials in one specification, the present grades A, B, and C, now covered in the widely used bolting specification A 96, are being incorporated into the present Tentative Specifications A 193. No major change is made in the three existing grades which thus would appear with detailed physical and only minimum chemical requirements. Making this move, references to specific temperature limitations are deleted from Specifica-

tions A 193 and at the same time certain other needed changes are covered.

With reference to the revisions in the specification for lap-welded and seamless steel pipe for high-temperature service A 106, in addition to the editorial changes providing for deletion of references to any specific temperatures, the title and scope clauses are to be clarified to indicate that this is *carbon* steel and further because a good grade of lap-welded pipe is covered in A 53 and since A 106 is intended for the high-temperature field where lap-welded pipe is restricted, the specifications will cover only seamless pipe, deleting references to the welded material.

End-Quench Test for Hardenability:

This test (A 255) for determining hardenability characteristics of steel has been very widely used, and thousands of copies of the chart for plotting the curves have been distributed. The special subcommittee of A-1 which is in charge, headed by E. W. Upham, Chief Metallurgist, The Chrysler Corp., has devoted much consideration to ways of improving the chart, and the new chart, it is believed, will meet a number of objections that have been raised to the older form. Furthermore clarification of the methods will improve the whole procedure. Minor changes were made in the old chart as it was necessary to reprint it from time to time, improving the utility and not affecting the plotting. After lengthy consideration, the special subcommittee has concluded on the basis of results from a widely distributed questionnaire, consultation with producers and users, and their own deliberations, that a reduced chart scale would be desirable, providing among other things for easier recording of data, better filing, etc. Perhaps the most serious objection to the new chart is that it will prevent direct comparison with hardenability curves previously plotted on the former standard chart. Rather than attempt to keep both charts in the standard, the subcommittee unanimously agreed to incorporate the new chart. A facsimile appears on page 39. It is available in pad form of 50 sheets at \$2.00 per pad or 3 pads for \$5.

Tentative Revisions of Standards.—Revisions in the copper brazed tubing standard, Specifications A 254, primarily will permit the assignment of working stresses which will be representative of the various types of this material. When written, the specifications were designed to cover all kinds of tubing produced, and one of the types, a double wall 360 deg. brazed type, can withstand much higher pressure than a butt brazed type, for example.

Revisions in the nut specification A 194 clarify the requirements for class "O" nuts, including the drift test and the chemical requirements.

Committee A-1 on Steel hopes very soon to submit to the Committee on Standards, proposed new specifications for chrome-molybdenum seamless pipe for high-temperature service. There is great demand for this specification covering a material which it is hoped will inhibit graphitization about which there has been so much concern in recent months.

Committee B-1 on Copper and Copper-Alloy Wires:

In the three specifications covering rope lay stranded conductors having bunch-stranded members (B 172), concentric-stranded members (B 173), and also for bunch-stranded copper conductors (B 174), Committee B-1 has modified the section covering variations in area and since these specifications are tentative the revisions are being incorporated immediately.

Committee D-2 on Petroleum Products:

With the cessation of hostilities, the committee considered that the Emergency Alternate EA-D 97 which was developed for the purpose of expediting military shipments in the case of very low pour point test oils by speeding up the cooling rate, could be dropped, and for the same reason EA-D 524 providing for the use of an alternate glass cooking bulb in case stainless steel bulbs could not be secured—this involving the test for carbon residue—might also be dropped.

However, the Emergency Method of Test for Color of U. S. Army Motor Fuel (all purpose) was re-

affirmed and will remain in the emergency status for another year.

Thermometers:

The revision in the Tentative Specifications for A.S.T.M. Thermometers (E 1 - 44 T) covers the inclusion of a new mercury thallium thermometer which is used in the Kinematic Test of Petroleum Products at Low Temperatures. This new thermometer, designated 43 F-45 T, has a temperature range of -61 to -29 F., with a total length of 400 to 412 mm., and graduations or subdivisions in 2 F. increments.

Foundry Pig Iron:

The new tentative specifications covering foundry pig iron will replace a standard which has remained unchanged since 1924. It has been apparent for some time that new specifications would be desirable. The new tentative, which will carry the designation A 43 - 45 T, provides for special agreements with respect to carbon and so-called "tramp" elements, and the standard grades which are set up are based primarily on phosphorus content. The material must conform to silicon, sulfur, phosphorus and manganese contents as detailed in tables of chemical compositions. According to the specifications, pig iron normally would be produced by reduction of iron ores in the blast furnace, but the specifications apply to cast iron that is produced by other smelting or melting processes used for the same general purpose as the blast-furnace product.

There has been considerable discussion and comment in the subcommittee responsible for drafting the specifications and it is felt the new tentative represents the best compromise that it is possible to reach.

Research

"THE word *research* implies a continuing process. It is unlikely that the physicists, chemists, and engineers of our country will ever stop prying into the secrets of fundamental science. In the words of Dr. Coolidge, 'A research laboratory is essentially a group of men in a congenial atmosphere, engaged in extending the frontiers of knowledge.'"

—*GE Campus News*

900 at Detroit Meeting Hear Kettering and Townsend

BY ACTUAL count 937 members of the Society and its technical committees, their friends, associates, and guests attended the session sponsored by the Detroit District on October 25 and heard two addresses on the general subject, "Research Revolutionizes Materials." Unquestionably those present felt well repaid for their attendance because of the very interesting presentations given by A.S.T.M. President John R. Townsend and C. F. Kettering, Vice-President, General Motors Corp., and a long-time A.S.T.M. member. The attendance at this district-sponsored session establishes a new high for numbers attending any A.S.T.M. meeting. Even the dinner preceding the session was a large one with about 425 present, almost the capacity of the dining room of the Engineering

Society of Detroit where the events took place.

At the dinner, Martin Castrium, District Chairman, introduced Executive Secretary C. L. Warwick, who in a 15-minute informal talk covered many of the interesting developments in A.S.T.M. work, referring to the reorganization of the administrative staff, the progress on the permanent Headquarters building, the development of several new administrative and technical committees, some of which were of particular interest to the industry centering in Detroit, and emphasized that A.S.T.M. was continuing its great activity on many fronts involving materials, research, specifications, tests, and standardization.

Since it is planned to publish Mr. Townsend's paper and Mr. Ketter-

ing's address are being published (see other pages of this BULLETIN), no additional comments seem necessary here, other perhaps than to point out that both speakers stressed the importance of the work of the Society. Each agreed that America's acumen and facility in mass production, at the same time keeping materials and products in line with latest advances, were the basic elements which permitted us to defeat the Germans and the Japs.

In the October BULLETIN mention was made of the various Detroit District Committee members who assisted Chairman Martin Castrium in planning and carrying through so successfully this outstanding meeting. These men are to be congratulated on arranging an event which was of such great value in promoting a better knowledge of the value of the Society's work in its chosen fields.

Messrs. Townsend and Boyd at Chicago District Meeting

UPWARDS of 225 A.S.T.M. members, members of the Western Society of Engineers and others heard two very interesting addresses at the meeting sponsored by the Chicago District on October 24. President J. R. Townsend, Materials Engineer, Bell Telephone Labs., Inc., New York, presented his paper "Research Revolutionizes Materials," which is published in this BULLETIN, and Vice-President T. A. Boyd, Head, Fuel Dept., Research Laboratories Division, General Motors Corp., Detroit, spoke on the topic "From Research—New Facts—New Materials—New Products." Since it is planned to publish Mr. Boyd's address, probably in the January BULLETIN, all that need be noted here in advance is that it is interesting reading, and will appeal to almost every member, even though the principal discussion relates to the chemical and chemical processing fields. From his long association in research, Mr. Boyd is in a splendid position to evaluate the fruits of research, and the evidence given in his paper demonstrates conclusively the continuing value of search for more and better information on materials.

It was an irony of fate that District Chairman J. F. Calef, Automatic Electric Co., after directing plans for the very successful meeting, should have been taken ill some days prior to the session, and was in the hospital recovering from gripe and related complications at the time of the meeting. (A recent report indicates he is coming around nicely.) In his absence, Vice-Chairman J. de N. Macomb, Inland Steel Co., presided, introducing the Technical Chairman, Past-President H. H. Morgan.

The meeting was a joint one with the Chemical and Metallurgical sections of the Western Society of Engineers, and many W.S.E. people were present.

Prior to the session, an informal dinner was held with members of the District Committee, speakers, and other invited guests present, including Executive Secretary C. L. Warwick, who extended a word of greeting at the session.

As mentioned in a separate news article, one of the features of the meeting was the presentation of the 1945 Dudley Medal to Prof. William N. Findley of the University of Illinois.

In planning the meeting and handling various arrangements, Program Chairman G. E. Stryker, Bell & Howell Co., was particularly active, and District Secretary J. J. Kanter, Crane Co., cooperated closely.

District Meetings in Cleveland and New York

THE January BULLETIN will carry news accounts of what promise to be two very interesting meetings held in Cleveland on December 4, and New York on December 11, under the auspices of the respective A.S.T.M. districts.

In Cleveland, President J. R. Townsend will give his address on "Research Revolutionizes Materials" and joining him as one of the features of the technical program will be Dr. Clyde E. Williams, Director, Battelle Memorial Institute, and Chairman of the War Metallurgy Committee, whose talk will cover "Post-War Materials."

In New York, the subject will be motor fuels, with Dr. J. Bennett

Hill, Manager, Development Division, Sun Oil Co., Marcus Hook, Pa., covering the subject "The

War Pays Benefits to the Motorist." Society officers will be present at each of the meetings, and members

of a number of other local sections and societies have been invited to attend.

Three Hundred Hear President Townsend, Doctor Bates, at Pittsburgh Meeting on Research at Home and Abroad

UPWARDS of 300 members, their associates and friends, heard A.S.T.M. President John R. Townsend, Bell Telephone Laboratories, Inc., and Dr. A. Allan Bates, Westinghouse Electric Corp., at the Pittsburgh District Meeting on Thursday, November 29. Thomas Spooner, Chairman of the Pittsburgh District, Manager, Engineering Lab. and Standards Dept., Westinghouse Electric Corp., presided. He and P. G. McVetty, District Secretary, Mechanical Engineer, Research Labs., Westinghouse, had planned the meeting program and carried through various arrangements with close cooperation from other district members including Dr. S. M. Phelps, Director of Research and Tests, Refractories Fellowship, Mellon Institute of Industrial Research. The meeting was held in the Mellon Institute Auditorium which provides such fine facilities for technical meetings.

Mr. Townsend delivered his paper, "Research Revolutionizes Materials," published elsewhere in this *BULLETIN* and which it is believed will be of interest to all A.S.T.M. members. The meeting was opened with a short talk by A.S.T.M. Executive Secretary C. L. Warwick, who referred to the intensive evaluation of all phases of A.S.T.M. work and future activities that have been carried out by the Study Committee, and commented on a number of recommendations, all of which have been, or will be, covered, in the *ASTM BULLETIN*. He referred to some of the newer work involving simulated service testing, the organization of a new committee on quality control just being announced; also work on ultimate consumer goods in which connection he stressed the great care which the committee in charge is giving to all steps taken to make sure that the activities will be on a sound basis and be such that the Society's technical work can be of maximum benefit.

Dr. Bates, Head, Chemical and Metallurgical Div., Westinghouse Research Labs., covered phases of his extensive trip through France and into Germany as part of an important War Dept. mission. He was in Europe for many months beginning November, 1944, and as a result of his intensive travels and studies there, has reached some very interesting conclusions on German research. His topic was "Tracking Down Research in Wartime Germany."

The objective of this mission, which included top American scientists, was to capture German scientific personnel, evaluate their work, and particularly to be alert for any work on the subject of nuclear physics or atomic bombs and related ultrascientific projects. It was startling to have him point out that the Germans apparently did not consolidate their scientific research in an effective way until early in 1944 when a central office was established. Dr. Bates was one of the first to get into this building, an old castle, well ahead of the Armed Forces at the time when the crack-up came.

The great majority of German scientists were willing without undue pressure to talk about their work and thought that it should continue since a good deal of it was directly applicable to peacetime pursuits. Some few of the scientists, particularly in the top brackets, were "good?" Nazis.

In many localities German industrial plants were built on the fringes of the older towns where the mechanics and working people resided. Consequently, he found quite a number of manufacturing plants virtually undamaged, but the town completely wiped out by bombing, this being the only effective means in these instances of providing a practically complete work stoppage.

Dr. Bates stressed his convictions that the United States must take a

dynamic lead in effecting a world organization to insure permanence of peace because of the horrible implications in the thought of another war. He stressed that regardless of a world government, the one big asset which the United States has had and which he feels must be made to continue is our lead in scientific research, process control and mass production. Concerning World War II it was the overwhelming force and modernness of our arms which brought the crushing victory. Even the Germans were amazed at the flood of mechanized equipment which came at them. He stressed that with only a few hundred thousand men and a few completely mechanized divisions the Germans had overrun practically all of Europe.

One of the points he emphasized was the importance of insuring that there is no letup or gap in the education and training of our engineers and scientists so that there will always be a large reservoir of competent personnel.

4 Battelle Publications

A 72-PAGE catalog of the publications and patents which have resulted from fifteen years of fundamental and applied Battelle research has just been published by Battelle Memorial Institute, Columbus, Ohio. The catalog lists more than eight hundred journal contributions, books, and patents between the years 1929 to 1944, inclusive. Many interesting technical papers by Messrs. Gillett, Lorig, Russell, Cross, and numerous others on the Battelle Staff have appeared in *A.S.T.M. Proceedings*, *BULLETIN*, and in special publications, these being noted in this Battelle bibliography. The catalog includes subjects in the fields of organic chemistry, electrochemistry, chemical engineering, graphic arts, welding technology, applied mechanics, mineral dressing, industrial physics, ceramics, fuels, and metallurgy.

A copy of the catalog will be furnished on written request on university or company letterhead.

Steel Subcommittee Meetings—Many Emergency Items Withdrawn

AT MEETINGS of several of the large subcommittees of Committee A-1 on Steel, held in Philadelphia on November 5 and 6, many revisions in existing specifications were approved for letter ballot, but probably the major action common to several of the groups was the decision to withdraw immediately many of the large number of emergency alternate provisions which had been used widely during the war emergency to expedite the procurement of various products, and at the same time conserve critical alloying elements. Groups responsible for specifications covering pipe and tubing, steels for boiler and other pressure vessels, forgings, and the Advisory Committee held lengthy meetings.

Among the changes eventually to be incorporated in various pipe and tubing specifications are the following: (1) Increasing the maximum permissible manganese content in certain carbon-moly and alloy tubing specifications; (2) adding to the alloy steel heat exchanger and steel tubing specifications A 199 and A 200 certain new classifications formerly covered in pink slips; and (3) making numerous changes in several electric welded tubing specifications, which have been found desirable and for which there has been considerable consumer demand. Another which will involve quite a number of pipe and tubing specifications is a provision for a formula to determine minimum elongation values where the wall thickness lies between the $\frac{1}{32}$ in. increment, as shown in the current specifications. Based on extensive study by manufacturers, Subcommittee IX acted to withdraw many of the emergency

provisions in the pipe specifications and to incorporate certain provisions in the standards. Similar actions were taken by the section responsible for pipe specifications for high-temperature service. Further details will be announced following committee letter ballot. The committee is studying the question of "average" and "minimum" wall thickness in view of the desire in boiler work to use minimum wall values. Some industries use "average," but the committee appointed will study this whole situation.

In the field of forgings two important items were discussed at length, one the question of a suitable standardized macroetch test with classified requirements which could be incorporated in specifications, probably of a visual chart nature. While the problems of developing suitable macroetch gradings which could be used as a basis for acceptance and revision is very complicated, there has been a special group appointed. Material developed at Watertown Arsenal has been widely used in connection with the acceptance of ordnance material, and it is felt desirable that this be extended.

Numerous changes eventually will be recommended in the specification for alloy steel forgings for locomotives and cars (A 238) including clarification of the requirements on boring and wall thickness of bored forgings, and on the matter of adding another class which would provide higher physical properties than now set up. Tensile strengths might range up to 140,000 psi. While a number of railroads use forgings in these ranges in many cases they are limited to specific

applications and the committee wishes to have further information before proposing such higher strength forgings.

In the field of steel for boilers and other pressure vessels, there was much discussion of match marking of boiler and firebox plates. While this is considered very important by railroad and other interests, the use of rotary shears in several of the newer plate mills may require some other system of identification in order not to impede production. It is very difficult for the operator with the newer mill to shear right at the match marked sections. Specific recommendations are being developed in a special section.

In the widely used specification for boiler and firebox steel, A 30 which now has three distinct grades, grade A firebox will have the tensile strength range raised 3000 psi. to be the same as the flange requirements, now 55,000 to 65,000 psi. Grade B, 48,000 to 58,000 psi. tensile strength, will stay as is. Thus these requirements will be in line with latest A.A.R. recommendations. An increase in manganese up to 0.80 per cent will be permitted.

There is a demand that the specifications for low-carbon nickel-steel plates (A 203) be changed to permit thicknesses up to 6 in. Recommendations will be made in the near future. The question of impact requirements to cover carbon and alloy plates for subzero temperature service was discussed and a survey is to be made. Emergency provisions, EA A 70 and EA A 89 are to be canceled. Another revision to be voted on will provide that where material is to be stress relieved after fabrication, the physical tests will be made on specimens which represent plates as treated.

Activity in Committee B-4 on Materials for Radio Tubes

VERY considerable progress was reported by the Section on Cathodes of Committee B-4's Subcommittee VIII on Metallic Materials for Radio Tubes and Incandescent Lamps at its meeting in New York on November 14. Last winter this section was constituted

to develop a standard test for evaluating the emissivity of cathode nickel. The interest of the electronic tube industry was evidenced by the very large attendance at the recent meeting.

A standard emissivity test will be of particular value in enabling the

manufacturers of the filament material and the consumer to check on the values, and thus provide a recognized procedure for acceptance or rejection. The manufacturer will be able also with the test to insure a control of quality which should result in a minimum of rejection claims and related consequences.

This work is under the general direction of the chairman of Subcommittee VIII, S. A. Standing, Chief Engineer, Electronic Tube Division, North American Philips Co., Inc., and Section A is under the direction of T. A. Briggs, RCA Laboratories, Radio Corp. of America. The work envisages a long-term program to investigate the effects of cathode material and its processing, on emissivity. The approach is being made by using a standard diode tube through which data on several test melts of nickel can be classified by a figure of merit. (A diode tube is a simple two-element tube.) As the classifications show sufficient performance differences, analyses will be made chemically, metallurgically, and spectrographically to bring out special characteristics.

The tube subgroup of the cathode section has collected information on eight test melts to date, one of which has a much higher indicated rating than the others, and will be used as a temporary standard. The diode group, while working with tests on factory diodes, is also working with a laboratory diode in which an effort is being made to eliminate all possible variables. The chemi-

cal group is developing proposed specifications for coating mixtures for diodes and for cleaning cathode sleeves before coating. The metallurgical group is working on a number of subjects including the adoption of a standard nomenclature and a program for studying the best and worst heats by X-ray diffraction examination, by spectrographic comparison, and by metallurgical examination.

Two papers on work recently completed at the Massachusetts Institute of Technology Radiation Laboratory were presented. The first was by A. S. Eisenstein on Radiation Tests Using a Standard Laboratory Diode. The second was by A. Fineman on a Study of Interface Compounds and Their Resistance. A.S.T.M. X-ray diffraction data were used in this work.

At the meeting of Subcommittee VIII, progress was reported on the evaluation of magnetic permeability of slightly magnetic materials; on the method of test of metal-to-glass sealing alloys; and on methods of test and specifications for alloy wire, with particular reference to plated and clad wire for grid winding.

The Committee B-4 meetings were held at the Hotel Woodstock,

continuing through November 15 and 16. Mr. John W. Harsch of the Leeds and Northrup Co. was elected Vice-Chairman of the committee. Consideration was given to adopting a new name for the committee and "High-Temperature and Electrical Alloys" was tentatively chosen. This change in title will be referred to the Non-Ferrous Coordinating Committee for recommendation to the A.S.T.M. Executive Committee. The committee also decided to sponsor in 1946 a new compilation of the B-4 standards and methods of test.

Subcommittee VII is working on methods for determining yield strength of thermostat metals, and Subcommittee IX is studying a new program of resuming experimental work on the effect of atmospheres at high temperatures.

Subcommittee X on Methods of Test for Determining the Hardness of Contact Materials is suggesting modification in Method B 182 for Life Tests of Electrical Contact Materials and has prepared a new method of test for hardness measurement of contacts. It is planned to have the next meetings of Committee B-4 late in January or in early February.

Committee C-1 on Cement

At its two-day series of meetings in Washington on October 24 and 25, Committee C-1 on Cement, convening for the first time since 1944, elected F. H. Jackson, Public Roads Administration, Chairman of the committee to succeed P. H. Bates. The committee took action on a number of its specifications and tests and considered in detail the work of several subcommittees. Some 50 members were in attendance.

Work under way for sometime in the committee was culminated by acceptance for submission to the Society of three proposed new tentatives: (1) Method for Determining Darc's in Portland Cement; (2) Air-Permeability Test for Fineness of Portland Cement, and (3) Tentative Specifications for Portland-Blast Furnace Slag Cement. The last-mentioned specification,

appearing as an appendix to the 1945 Annual Report of Committee C-1, was revised in a few places and there was inserted a 25 per cent minimum limit on the slag content.

As announced in the October BULLETIN, P. H. Bates, Past President of the Society, has retired voluntarily from his long-time work at the National Bureau of Standards as Chief, Clay and Silicate Products Division, and also resigned his chairmanship of Committee C-1 which he held continuously since 1926. In electing Mr. Jackson the committee has chosen another long-time A.S.T.M. member who has taken a very active part in many phases of the work. A former member of the Executive Committee and at present a member of the Administrative Committee on Standards he also is a former chairman of Com-

mittee C-9 on Concrete and Concrete Aggregates.

A few notes on proposed changes in standards, all of which are subject to Committee C-1 letter ballot, follow:

The widely used specifications for portland cement, C 150, providing five types, will be revised—specifically Section 9 involving rejection.

Specifications for air-entraining portland cement for concrete pavement, C 175, will have the title changed by dropping the phrase "for concrete pavement." Sections on rejection, packaging, and marketing will be clarified and the limits for entrained air in the standard mortar will be raised from 14 ± 4 per cent to 16 ± 4 per cent.

The tentative test for air content of portland cement mortar, C 185, will be revised so as to provide improvements in the design and use of the Burmister flow trough.

Certain details in the standard

method of sampling hydraulic cement, C 183, will be revised.

Current subcommittee work was

discussed, particularly the cooperative program sponsored by the Working Committee on Strength,

and certain proposals made by the Subcommittee on the Cement Reference Laboratory.

Committee D-3 on Gaseous Fuels Plans Accelerated Program

COMMITTEE D-3 on Gaseous Fuels held its first meeting since conclusion of the war in New York on October 23, 1945. The purpose of the meeting was to receive reports of activities of the individual subgroups and to plan for early completion of a number of test methods now in preparation. Reports presented by the chairmen of the various subcommittees indicated a great deal of progress notwithstanding the many difficulties presented during the past several years when pressure of war work interrupted normal activities.

The Chairman of Subcommittee on Collection of Gaseous Samples, S. J. Modzikowski, reported that a draft of a proposed method for sampling liquefied petroleum gases had been prepared for distribution in the subcommittee. It is hoped to present it to Committee D-3 for approval at the time of the spring meeting. This subcommittee also has in preparation methods of sampling natural gases.

R. S. Jessup, the new Chairman of the Subcommittee on Determination of Calorific Value of Gaseous Fuels, reported that much progress had been made in preparation of a tentative method of test for calorific value of gaseous fuels by the water flow calorimeter. It is expected this method will be in

readiness for approval early next year.

An exhaustive investigation of specific gravity instruments made by the National Bureau of Standards and covered in a very complete report issued to committee members some time ago has received much attention. While this report has not been published, an abstract appeared in the *A.G.A. Monthly* for June, 1944. In view of the interest displayed it is expected that the National Bureau of Standards will be able to publish the report within the very near future. In the meantime a number of improvements have been made in the instruments originally examined, and it is hoped that further tests may later be performed to determine their effectiveness.

Correspondence has been exchanged by the Chairman of Committee D-3 with a manufacturer now producing an instrument for determination of water vapor employing a principle used at the National Bureau of Standards. This device has already been found of much use in determination of water in oxygen. It is proposed to conduct tests of the new apparatus for both field and laboratory purposes at Pennsylvania State College.

Analysis of standard samples distributed by the Subcommittee on

Complete Analysis or Chemical Composition of Gaseous Fuels is to be covered by two papers. One has been completed and will appear in the *Journal of Research* of the National Bureau of Standards at an early date. The second, is still in preparation and will be published later. Considerable attention has also been devoted by Martin Shepherd, chairman of the chemical analysis subcommittee, to the use of a mass spectrometer for analysis of gas samples in connection with the Rubber Reserve's cross-check program. Some 30 laboratories have been contacted for conduct of cooperative analysis, samples for which are being prepared by the National Bureau of Standards. Results will afford a good opportunity for comparison of this method with chemical analysis methods now in use.

Committee D-3 on Gaseous Fuels is devoting major attention to the development of test methods for publication as tentative in the near future. It now appears that with return of peace, much greater speed can be made in their preparation than was possible during the war. It is confidently expected that a number of methods now in preparation will be in readiness for approval by Committee D-3 within the next few months. Their availability will be of great assistance to anyone desiring to make use of such methods in specific problems which may arise.

Standards Punched to Fit Loose-Leaf Binders

Stamped Binders Also Available

DURING the past several years we have received inquiries from time to time concerning provisions for assembling in loose-leaf form selected groups of separate A.S.T.M. standards. In some cases the user was interested in large groups of standards and tentatives selected from all three

parts of the Book of Standards, while others were interested in only a small, specialized group.

The Executive Committee has recently authorized having standards and tentatives, all of which are issued in separate pamphlet form, punched to conform with the standard three-hole punching for

a 6 by 9-in. sheet. All of the separate standards will, therefore, now fit any loose-leaf binder whose rings or posts conform to standard spacing ($3\frac{1}{2}$ in. on centers).

The charges for separate standards are as follows:

1 to 9 copies—	25 cents each
10 to 24 copies—	20 cents each
25 to 99 copies—	17½ cents each
100 to 250 copies—	15 cents each
250 to 500 copies—	12½ cents each
500 to 1000 copies—	10 cents each

Lots may be of the same or assorted standards.

Binders Available:

The Executive Committee has also authorized Headquarters to make available binders to hold these punched A.S.T.M. standards and thus provide for maximum utility. The "Executive Type Binder," which is an expanding post binder, was selected. The posts are of the telescopic type and their supports are so fastened to the binder that they allow a $\frac{3}{8}$ -in. expansion beyond the capacity of the book when the covers are open.

This allows the standards to fall apart flat and enables the text to be read easily into the inner margins. The binder closes without clinching and thus avoids eventual tearing of sheets. The binder works equally well when filled to capacity or when only a few standards are included. Another feature is that the posts, being of a telescopic nature, enable standards readily to be replaced or added at various points throughout the book.

Binders are available in two

sizes, a $1\frac{1}{2}$ -in. capacity which holds a maximum of approximately 800 pages or an average of 120 standards and a $\frac{7}{8}$ -in. capacity which holds a maximum of approximately 400 pages and an average of 60 standards. Both the $1\frac{1}{2}$ and $\frac{7}{8}$ -in. binders can be secured from Society Headquarters at \$2.25 each. The binders are stamped in genuine gold on the back strap, reading, "Selected A.S.T.M. Standards." They should be available for distribution early in January.

Part II Standards Supplement, Other Publications, Available Soon

Work is being pushed on the 1945 Supplements to the Book of Standards, and these 500 to 600-page books will be distributed just as soon as the respective parts become available. Part II, Non-metallic Materials—Constructional, will be the first to go in the mails sometime in December to be followed by Part I, Metals, and Part III, Nonmetallic Materials—General, a few weeks later.

Since the October BULLETIN, which carried announcements of certain books, two special technical books have been completed, namely, the Symposium on Magnetic Particle Testing and the Report on Behavior of Ferritic Steels at Low Temperatures. The Magnetic Particle Testing Symposium in addition to the several papers and interesting discussion covering this widely used test and its application in various fields, is supplemented by the inclusion of the two procedures developed in Committee A-1 on Steel covering magnetic particle

testing and inspection of commercial steel castings (A 272) and heavy steel forgings (A 275). A special prospectus has gone to the members covering this book.

Likewise an order blank has been sent to the members on the Report on Behavior of Ferritic Steels at Low Temperatures which was prepared by Dr. Gillett providing data developed from a War Metallurgy Committee sponsored project at the University of Kentucky. In addition to these voluminous data with a large number of figures, charts, and tables, Dr. Gillett has included considerable other material which has become available since his 1941 publication on impact testing which was prepared for the Joint Committee on Effect of Temperature on the Properties of Metals. This report, publication of which was approved by the OPRD, is issued in two parts and is available to members at \$3, the list price being \$4. It aggregates some 230 pages with over 250 tables, illustrations, etc.

Among these were the following:

W. Rayner Hebblewhite	Australia
Kaare Heiberg	Norway
Percy Good and (Miss) G. E. Harrison	Great Britain
H. E. Glahn	Denmark
Galbraith and Langford	New Zealand
S. T. Shang and Dickson	
Reck	China
General P. Salmon	France

A number of these officials were, of course, quite familiar with A.S.T.M. but were interested in renewing past acquaintanceships and in discussing problems of mutual interest. In several instances, however, the representatives were particularly interested in learning of the A.S.T.M. setup and we were able to outline the functions of the Society.

The Society's work has had close cooperative relations with the older standards agencies, as, for example, the British Standards Institute, Canadian Standards Association, Standards Association of Australia, and New Zealand Standards Institute, and we have had exchange relations with these organizations for a number of years. It has been a pleasure to meet with these delegates and to renew our past relations with the cessation of hostilities.

UNSCC Visitors at A.S.T.M. Headquarters

IN THE October issue of the ASTM BULLETIN, mention was made of a conference held under the auspices of the United Nations Standards Coordinating Committee to discuss the establishment of a new international standards organization. This conference was

attended by representatives of standardizing agencies from a number of countries throughout the world. Following the conference, these delegates, many of them executives of the respective standards agencies, paid visits to A.S.T.M. Headquarters.

Instrument Society Organized

AT THE organization meeting of the Instrument Society of America in Pittsburgh in October some fourteen local groups sent representatives. The constitution was discussed and other matters incident to the organization of this new group were covered. Albert F. Sperry, *pro tem* president, presided. Richard Rimbach is temporary secretary of this new group.

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Statistical Comparison of Rayon Tire Cord Fatigue Testing Machines—C. B. Budd and L. Larriek. No. 136, October, p. 19.

Standard Fatigue Tester for Use by the Rayon Manufacturers—Report to Committee D-13—W. H. Bradshaw. No. 136, October, p. 13.

Tires

An Automotive Tire Fatigue Machine—John N. Kenyon. No. 136, October, p. 9.

V, W & X

Vinsol Resin

Effect of Heat on Portland Cements Containing Vinsol Resin—Leonard Bean and Albert Litvin. No. 135, August, p. 30.

Walkway Materials

A New Machine for Measuring Wear Resistance of Walkway Materials—A. W. Cizek, Jr., D. H. Kallas, and H. Nestlen. No. 132, January, p. 25. Discussion, No. 134, May, p. 62.

Water

Proposed Methods for Determination of Dissolved Oxygen in Industrial Waters. No. 137, December, p. 19.

Waterproofing

A Rubber Housing for Waterproofing the Bonded-Wire Strain Gage—Douglas McHenry. No. 133, March, p. 18.

Wear

A New Machine for Measuring Wear Resistance of Walkway Materials—A. W. Cizek, Jr., D. H. Kallas, and H. Nestlen. No. 132, January, p. 25. Discussion, No. 134, May, p. 62.

Wood

The Effect of Specimen Shape on the Compressive Strength Properties of Laterally Supported Plywood Specimens—J. A. Liska. No. 133, March, p. 33.

A Simplified Method for the Determination of the Specific Gravity of Wood and Plastics—E. George Stern and Paul S. Dear. No. 135, August, p. 35.

Some Factors in the Interpretation of Small-Scale Tests for Fire-Retardant Wood—F. W. Gottschalk. No. 136, October, p. 40.

X-ray

General Properties of Industrial Radiographic Films—Herman E. Seemann. No. 134, May, p. 17.

X-ray Diffraction Data for Chemical Analysis. No. 135, August, p. 64.

Index to Authors of Technical Papers 1945 ASTM Bulletins

While this Author Index does not list authors according to alphabetic sequence and the titles of some of the papers are condensed, it is believed the information as presented will be of service. Further details are given in the Subject Index.

January 1945—No. 132

- V. E. GROTLISCH AND H. N. BURSTEIN—The Determination of the Terpene Alcohol Content of Steam-Distilled Pine Oil
H. C. MOUGEY—Life Testing of Lubrication Oil
F. C. FLINT—Glass—A Summary of Its Development as an Art and as a Science
A. W. CIZEK, JR., D. H. KALLAS, AND H. NESTLEN—A New Machine for Measuring Wear Resistance of Walkway Materials
VICTOR SELIGER—A Suggested New Parameter for Fatigue Strength Analysis
G. D. MCCARTHY, A. E. JUVE, H. BOXSER, M. SANGER, S. R. DONER, E. N. CUNNINGHAM, J. F. MCWHORTER, AND R. H. CROSSLEY—High Temperature Oven Aging of Oil-Resisting Synthetic Rubber Compounds

March 1945—No. 133

- R. E. PETERSON—Relation Between Life Testing and Conventional Tests of Materials
C. H. MAHONEY, A. L. TARR, AND K. A. SKEIE—A Variable Cycle Alternate Immersion Corrosion Testing Machine
DOUGLAS MCHENRY—A Rubber Housing for Waterproofing the Bonded-Wire Strain Gage
E. C. WRIGHT—The Manufacture of Heavy-Wall Pipe
FRANK N. SPELLER—Memo on Cavitation
JAY C. HARRIS—Metal Cleaning: I—Indirect Performance Tests
H. A. McCONVILLE—A.S.T.M. Lubricating Grease Test Methods
T. G. ROEHNER—Developing Test Methods for Lubricating Greases
J. A. LISKA—The Effect of Specimen Shape on the Compressive Strength Properties of Plywood Specimens

May 1945—No. 134

- W. V. BASSETT—Strain Gage Procedures for Structural Tests on Ships
HERMAN E. SEEMANN—General Properties of Industrial Radiographic Films
ROBERT BURNS—Dimensional Stability of Plastics
W. A. ZINZOW—Flexural Properties of Plastics
GEORGE A. HEIRHOLZER AND R. F. BOYER—An Automatic Heat Distortion Recorder for Plastics
E. M. SCHOENBORN, GEORGE R. PROCTOR, AND JAIME CARVAJAL—The Flexural Strength of Laminated Plastics
H. P. FERGUSON, C. L. POPE, F. C. LINN, G. H. VON FUCHS, H. R. WOLF, C. M. LOANE—Symposium on Neutralization Number
L. F. ROEHMANN—Electrical Conductivity of Conductors

August 1945—No. 135

- REAR ADMIRAL LEWIS B. COMES—Preparing for Victory with the Sea-Bees
P. H. BATES, President's Address—Preparations for the Future of the A.S.T.M.
S. LIPSON—A New Coating Thickness Gage
R. A. QUADT—Impact Specimens for Aluminum Sand Casting Alloys
A. A. MOORE AND J. C. McDONALD—Compression Testing of Magnesium Alloy Sheet
LEONARD BEAN AND ALBERT LITVIN—Effect of Heat on Portland Cements Containing Vinsol Resin
E. GEORGE STERN AND PAUL S. DEAR—Determination of the Specific Gravity of Wood and Plastics
E. L. WALTERS AND D. L. YABROFF—Determination of Gum Values by the I.P.T. and A.S.T.M. Air Jet Gum Methods
RAUL VALLE-RODAS—A New Method for the Mechanical Analysis of Soils
J. B. GOLDBERG—Tomorrow's Textiles—Yesterday's Test Methods

October 1945—No. 136

- JOHN N. KENYON—An Automotive Tire Fatigue Machine
W. H. BRADSHAW—Standard Fatigue Tester for Use by the Rayon Manufacturers
C. S. VENABLE—Comparative Fatigue Test Data
C. B. BUDD AND L. LARRICK—Statistical Comparison of Rayon Tire Cord Fatigue Testing Machines
LOUIS C. BARAIL—A Suggested Method for Thorough Testing of Antiseptic Fabrics
JAY C. HARRIS—Metal Cleaning: II—Soil Removal Performance Methods
F. W. GOTTSCHALK—Interpretation of Small-Scale Tests for Fire-Retardant Wood

December 1945—No. 137

- J. R. TOWNSEND—Research Revolutionizes Materials
C. F. KETTERING—An Address on Standards, Research, etc.
COMMITTEE D-19—Determination of Dissolved Oxygen in Industrial Waters
GEORGE G. MANOV AND S. F. ACREE—The pH of Some Standard Buffer Solutions and the Calibration of Glass Electrode pH Meters
GEORGE W. JERNSTEDT—Surface-Conversion Coatings

Statistics on Committees and Standards

ALL too infrequently is there an opportunity to develop some interesting facts or statistics on the work of the Society. While this situation, brought about by the concentration of the technical committees and the Staff on research and standards work and publications, is to be expected, occasionally some information can be compiled and recently a list has been prepared showing the years of organization of the various technical committees and the number of standards and

tentatives for which each of the technical committees is responsible.

Believing that this information will be of interest to our members, particularly to those serving on technical committees, it is published here. From these data it will be seen that while the Steel Committee is the oldest from the standpoint of service it does not have the most specifications and tests in its charge, this honor being accorded the Committee on Paint, Varnish, Lacquer, and Related Products. It is signi-

ficant that some of the relatively newer committees, on plastics for example, have quite a large number of standards, showing concentrated work. The number of standards and tentatives a committee may have is not necessarily an indication of its influence in a particular industry. The Committee on Cement, for instance, with only 19 standards finds its specifications very widely used, having tremendous influence wherever cement is produced or used. This same situation holds for many of the other technical committees.

A.S.T.M. CHRONOLOGY OF TECHNICAL COMMITTEES

YEAR OF ORGANIZATION	COMMITTEE	1904	1906	1909	1911
1898	A-1 on Steel	C-4 on Clay Pipe	A-5 on Corrosion of Iron and Steel		
1902	C-1 on Cement	C-5 on Fire Tests of Materials and Construction		A-2 on Wrought Iron	
	D-1 on Paint, Varnish, Lacquer and Related Products	D-2 on Petroleum Products and Lubricants		B-1 on Copper-Alloy Wires for Electrical Conductors	
		D-5 on Coal and Coke		D-9 on Electrical Insulating Materials	
1903	A-3 on Cast Iron	D-7 on Timber		B-2 on Non-Ferrous Metals and Alloys	
	A-6 on Magnetic Properties	E-1 on Methods of Testing (1920 reorganized)			
	D-4 on Road and Paving Materials	D-8 on Bituminous Waterproofing and Roofing Materials			
					C-6 on Drain Tile

COMMITTEE CHRONOLOGY

(Continued)

A.S.T.M. STANDARDS AND TENTATIVES AS OF OCTOBER 15, 1945

YEAR OF ORGANIZATION	COMMITTEE	COMMITTEE DESIGNATION	NO. OF STANDARDS	NO. OF TENTATIVES	TOTAL
1912	C-7 on Lime	A-1 on Steel.....	104	20	124
	E-5 on Standing Committees	A-2 on Wrought Iron.....	15	0	15
	D-11 on Rubber and Rubber-Like Products	A-3 on Cast Iron.....	7	7	14
		A-5 on Corrosion of Iron and Steel.....	12	6	18
1913	E-6 on Papers and Publications	A-6 on Magnetic Properties.....	1	1	2
		A-7 on Malleable-Iron Castings.....	2	2	4
		A-9 on Ferro-Alloys.....	8	0	8
1914	C-8 on Refractories	A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys.....	9	11	20
	C-9 on Concrete and Concrete Aggregates	B-1 on Copper and Copper-Alloy Wires for Electrical Conductors.....	11	5	16
	D-10 on Shipping Containers	B-2 on Non-Ferrous Metals and Alloys.....	12	12	24
	D-13 on Textile Materials	B-3 on Corrosion of Non-Ferrous Metals and Alloys.....	0	3	3
1915	C-11 on Gypsum	B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys.....	12	12	24
1916	E-4 on Metallography	B-5 on Copper and Copper Alloys, Cast and Wrought.....	30	34	64
1918	A-7 on Malleable-Iron Castings	B-6 on Die-Cast Metals and Alloys.....	2	4	6
		B-7 on Light Metals and Alloys, Cast and Wrought.....	5	19	24
1920	E-8 on Nomenclature and Definitions	B-8 on Electrodeposited Metallic Coatings.....	1	7	8
		B-9 on Metal Powders and Metal Powder Products.....	0	1	1
1922	B-3 on Corrosion of Non-Ferrous Metals and Alloys	C-1 on Cement.....	14	5	19
		C-4 on Clay Pipe.....	1	2	3
1923	A-9 on Ferro-Alloys	C-5 on Fire Tests of Materials and Construction.....	2	1	3
1924	D-17 on Naval Stores	C-6 on Drain Tile.....	1	0	1
	E-9 on Research	C-7 on Lime.....	13	4	17
1925	B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys	C-8 on Refractories.....	23	10	33
		C-9 on Concrete and Concrete Aggregates.....	28	7	35
1926	C-18 on Natural Building Stones	C-11 on Gypsum.....	13	1	14
		C-12 on Mortars for Unit Masonry.....	1	1	2
1928	B-5 on Copper and Copper Alloys, Cast and Wrought	C-13 on Concrete Pipe.....	4	0	4
	B-7 on Light Metals and Alloys, Cast and Wrought	C-14 on Glass and Glass Products.....	6	1	7
	Research Committee on Fatigue of Metals	C-15 on Manufactured Masonry Units.....	16	2	18
		C-16 on Thermal Insulating Materials.....	7	6	13
1929	A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys	C-18 on Natural Building Stones.....	7	1	8
	E-10 on Standards	D-1 on Paint, Varnish, Lacquer, and Related Products.....	109	28	137
1930	B-6 on Die Cast Metals and Alloys	D-2 on Petroleum Products and Lubricants.....	47	20	67
		D-4 on Road and Paving Materials.....	50	13	63
1931	C-12 on Mortars for Unit Masonry	D-5 on Coal and Coke.....	22	5	27
	C-13 on Concrete Pipe	D-6 on Paper and Paper Products.....	25	17	42
1932	D-19 on Water for Industrial Uses	D-7 on Wood.....	18	1	19
	E-2 on Spectrographic Analysis	D-8 on Bituminous Waterproofing and Roofing Materials.....	20	11	31
1935	D-3 on Gaseous Fuels	D-9 on Electrical Insulating Materials.....	28	30	58
	E-3 on Chemical Analysis of Metals	D-10 on Shipping Containers.....	0	3	3
1936	D-12 on Soaps and Other Detergents	D-11 on Rubber and Rubber-Like Materials.....	25	36	61
		D-12 on Soaps and Other Detergents.....	27	2	29
1937	C-14 on Glass and Glass Products	D-13 on Textile Materials.....	52	24	76
	C-15 on Manufactured Masonry Units	D-16 on Industrial Aromatic Hydrocarbons.....	0	19	19
	D-6 on Paper and Paper Products	D-17 on Naval Stores.....	4	6	10
	D-18 on Soils for Engineering Purposes	D-18 on Soils for Engineering Purposes.....	11	4	15
1938	D-20 on Plastics	D-19 on Water for Industrial Uses.....	8	5	13
		D-20 on Plastics.....	10	54	64
1941	B-8 on Electrodeposited Metallic Coatings	E-1 on Methods of Testing.....	10	9	19
	Advisory Committee on Corrosion	E-2 on Spectrographic Analysis.....	0	5	5
1943	D-16 on Industrial Aromatic Hydrocarbons	E-3 on Chemical Analysis of Metals.....	11	7	18
	B-9 on Metal Powders and Metal Powder Products	E-4 on Metallography.....	2	5	7
1944	D-14 on Adhesives	E-7 on Radiographic Testing.....	0	2	2
		E-8 on Nomenclature and Definitions.....	4	1	5
		Joint Research Committee on Effect of Temperature on Properties of Metals.....	2	0	2
		Joint Committee on Filler Metal.....	0	3	3
			852	495	1347*
* Uncorrected for duplication of count due to a standard being listed twice where it is under the joint jurisdiction of two committees.			TOTAL corrected for duplicate listings—1317		
TOTAL STANDARDS FOR ALL COMMITTEES					
1901.....	13	1925.....	447		
1905.....	18	1930.....	582		
1910.....	28	1935.....	794		
1915.....	110	1940.....	952		
1920.....	225	1945.....	1317		

NEW MEMBERS TO NOVEMBER 19, 1945

The following 34 members were elected from October 3 to November 19, 1945:

Chicago District

FIELDHOUSE, IRWIN B., Associate Chemical Engineer, Armour Research Foundation, Chicago, Ill. For mail: 250 Lake St., Oak Park, Ill.
ROEHRI, CARL, Manager, Federal Die Casting Co., 2222 N. Elston Ave., Chicago 14, Ill.

Detroit District

LOGAN, DAVID R., Parker Rust-Proof Co., 2177 E. Milwaukee Ave., Detroit 11, Mich.

New York District

WOBURN CHEMICAL CORP., K. Schroeder, Technical Director, 1200 Harrison Ave., Harrison, N. J.
BRAGG, SIDNEY J., Engineer, Mack Manufacturing Corp., 1120 S. Second St., Plainfield, N. J.
EKWALL, AXEL, Technical Attaché, Royal Swedish Legation in U.S.A., 630 Fifth Ave., New York 20, N. Y.
GOODY, R. B., Chief Engineer, Sherman and Co., 197 Canal St., New York 13, N. Y.

Philadelphia District

SUNROC REFRIGERATION CO., A. I. Martindale, General Manager in Charge of Sales Engineering, Glen Riddle, Pa.
ALOY, FELIX F., Metallurgical Engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa.
LONGBOTTOM, JOHN H., Head, Chemical Research, A. H. Wirz, Inc., Chester, Pa. For mail: 568 Mohawk Ave., Norwood, Pa.

Pittsburgh District

HUBBELL, DEAN S., Senior Fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa. For mail: Saxonburg Blvd., R. D. 2, Pittsburgh 15, Pa.
MAYO, WARREN H., Assistant Manager, Metallurgical Dept., Carnegie-Illinois Steel Corp., 763 Frick Building Annex, Pittsburgh 19, Pa.
PRICE, J. W., JR., Manager, Railroad Materials and Commercial Forgings Bureau, Metallurgical Div., Carnegie-Illinois Steel Corp., 770 Frick Building Annex, Pittsburgh 19, Pa.
THOMPSON, CLYDE L., Laboratory Manager, Harbison-Walker Refractories Co., Hays Laboratory, Pittsburgh 7, Pa.

St. Louis District

LAMBERT PHARMACAL CO., H. S. Conway, Chemist, 2117 Franklin Ave., St. Louis 6, Mo.
HANKERSON, F. P., Executive Secretary, Associated Cooperage Industries of America, Inc., 408 Olive St., St. Louis 2, Mo.

Southern California District

BREWER, GIVEN A., Aircraft Structures Engineer, 290 Thalia St., Laguna Beach, Calif.

Western New York-Ontario District

BOWSER CO., LTD., S. F. J. Gelb, Research Engineer, 183 George St., Toronto, Ont., Canada.
MIRACLE ADHESIVE CORP., J. F. Perry, Vice-President, 852 Clinton Ave., Newark, N. J.

U. S. and Possessions

MINNESOTA & ONTARIO PAPER CO., M. S. Wunderlich, Director of Research, 500 Baker Arcade Bldg., Minneapolis 2, Minn.
TRANSCONTINENTAL & WESTERN AIR, INC., Dolores Riley, Chemist, 14 W. Third St., Kansas City 6, Mo.

BICKFORD, ROBERT TURNER, Architect, 215 W. Water St., Elmira, N. Y.
JACKSON, LLOYD R., Research Supervisor, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.
PANG, DAT QUON, Junior Civil Engineer, Materials Testing Lab., U. S. Engineer Dept. For mail: 938 N. Vineyard St., Honolulu 7, T. H. [J]*
SIMPSON, WILLIAM D., Chief Engineer, Seaboard Air Line Railway, 752 S.A.L. Railway Bldg., Norfolk 10, Va.
THOMPSON, W. E., Consulting Civil Engineer, Box 294, Belle Fourche, S. Dak.
WENSEL, HENRY T., Chief, Heat and Power Div., National Bureau of Standards, Washington 25, D. C.

Other than U. S. Possessions

DANSK STANDARDISERINGSRAAD, H. E. Glahn, Secretary, Vesterbrogade 1, Copenhagen, Denmark.
DUNLOP RUBBER CO., LTD., GENERAL RUBBER GOODS DIVISION, S. A. Brazier, Technical Manager, 2 Cambridge St., Manchester, England.
GREEN ARGENTINA, S. A., A. P. Antonio Aguirre, General Manager, Belgrano 831, Buenos Aires, Argentina.
ROLLS-ROYCE, LTD., T. G. Dickson, Technical Librarian, Nightingale Rd., Derby, England.
BERG, T. G. OWE, Head of Physical Research Lab., A. B. Bofors Nobelkrut, Bofors, Sweden. For mail: Box 1774, Bofors, Sweden.
BERGLUND, TORSEL, Chief of Metallurgical Research, The Sandvik Steel Works Co., Ltd., Sandviken, Sweden.
CANO FARO, RAÚL, General Manager, Cobre de Mexico, S. A., Callejon del Colegio No. 17, Box 9575, Atzacapotzalco, D. F., Mexico.

* [J]—Denotes Junior Member.

Personals . . .

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

MEYER CHISDES has returned to his pre-war position as Chemist in Charge of Chemical Laboratory of the Port of New York Authority, New York, N. Y. He was formerly Chemist, Hazeltine Corp., Little Neck, L.I.

EDMUND DUPLAGA, who was Shift Supervisor, Hercules Powder Co., Badger Ordnance Works, Baraboo, Wis., is now Senior Development Engineer, Goodyear Aircraft Corp., Akron, Ohio.

A. N. BENSON is now Physicist, Frankford Arsenal, Small Arms Ammunition Division, Philadelphia 37, Pa.

W. V. PRINCE, who was Manager, Plastics Division, Weatherhead Co., Cleveland, Ohio, is now with the Prince Industrial Plastics Corp., in Cleveland.

ALBERT H. POSTLE, who was Standards Engineer, Sperry Gyroscope Co., Inc., Garden City, N. Y., is now in the Engineering Department, Mycalex Corporation of America, Clifton, N. J.

RUSSEL A. MORRIS, formerly Mechanical Engineer, Anaconda Wire and Cable Co., Sycamore, Ill., is now Chief Engineer, The Sycamore Foundry, Maple Park, Ill.

DR. HERBERT JOHN GOUGH, 1933 A.S.T.M. Edgar Marburg Lecturer, is Engineer-in-Chief, Lever Brothers and Uni-

lever, Ltd., Blackfriars, London, England. During the war he filled the important responsibility of Deputy Controller-General of Research and Development, Minister of Supply, Strand, London, England.

CECIL J. BIER, who was Director of Research, H. L. Crowley and Co., Inc., West Orange, N. J., is now Chief Engineer, Biad Powder Metallurgy Co., Pittsburgh, Pa.

EDWARD M. SCHOENBORN is Head, Department of Chemical Engineering, North Carolina State College, Raleigh, N. C. He was formerly Associate Professor of Chemical Engineering, University of Delaware, Newark, Del.

O. HARRY SCHRADER, JR., formerly Chief Wood Technologist and Research Engineer, Timber Structures, Inc., Seattle, Wash., is now in the College of Forestry, University of Washington, Seattle, Wash.

CLARENCE H. SAMPLE, formerly a member of the Technical Staff of the Bell Telephone Laboratories, has joined Rheem Research Products, Inc., Baltimore, Md., as Chief Engineer. In this capacity Mr. Sample's chief task will be to coordinate technical matters among the Research Laboratory, Pilot Plant, field tests, and commercial applications for the company's product, Iridite. He will also work closely with the Sales and Marketing Departments in the role of an adviser on technical problems. Mr. Sample has been very active in A.S.T.M. technical committee work notably as secretary of Committee

B-8 on Electrodeposited Metallic Coatings.

FRANK W. YEAGER formerly Chemist, The Barrett Division, Allied Chemical and Dye Corp., Edgewater, N. J., is now Chemical Engineer, The Flintkote Co., East Rutherford, N. J.

HARRY P. CROFT has returned from Service as Lieutenant Colonel, Ordnance Dept., Cleveland Ordnance District, Cleveland, Ohio, to become Director of Technical Control and Research, Midwestern Div., Chase Brass and Copper Co., Inc., Cleveland, Ohio. Mr. Croft was connected with Chase before the war.

ROBERT A. BITTENBENDER, formerly Structural Engineer, Curtiss-Wright Corp., Airplane Division, Buffalo, N. Y., is now Technical Engineer, Jackson & Moreland, Engineers, Boston, Mass.

P. W. ROLLESTON formerly Director of Materials Supply, British Air Commission, New York, N. Y., is now with Aluminium Laboratories, Ltd., Banbury, Oxon, England.

HERMAN A. BOGEHOLD is now Assistant Manager, Production, Industrial Minerals, Ltd., Waterways, Alta., Canada, a subsidiary of Dominion Tar and Industrial Chemical Co., Ltd., Montreal. He was formerly Chief Chemist, Abasand Oils, Ltd., Fort McMurray, Alta., Canada.

ALFRED SCOTT TUCKER, formerly Development Metallurgical Engineer, General Electric Co., Lynn, Mass., has returned to this country after serving with

the Marine Corps in the Southwest Pacific to accept a position as Engineer with Baldwin Locomotive Works in San Francisco, Calif.

JOSEPH GRAY JACKSON, formerly Assistant Chief Engineer, Office Chief of Ordnance, Artillery Division, U. S. War Department, Washington, D. C., is now Patent Lawyer, William Steell Jackson and Son, Philadelphia, Pa.

FRED C. SMITH, who was Chief Metallurgist, Tube Turns, Inc., Louisville, Ky., is now Director of Quality. In this capacity he will supervise inspection in addition to his metallurgical activities.

G. ELLIOTT ROBINSON who was Assistant Section Head, Engineering Laboratories, Curtiss-Wright Corp., Airplane Division, Buffalo, N. Y., is now Test Engineer, M.I.T. Bomb Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

CURTIS CANTRILL, formerly Principal Highway Engineer, Highway Materials Research Laboratory, Kentucky State Highway Department, is now Engineer, Kentucky-Virginia Stone Co., Middlesboro, Ky.

FRANK W. DAVIS, Chief Metallurgist, E. B. Badger and Sons Co., Boston, Mass., has been elected Vice-President of the New York and New England District of the American Welding Society for a term of two years.

At the close of hostilities, only eight war plants in the entire nation were permitted to fly the United States Navy Bureau of Ordnance Flag and the All-Navy "E" Burgee with six white stars affixed—each star indicative of a renewal of the first "E" award made in World War II, the original "E" award having been made in July, 1941. Seven of the eight companies are A.S.T.M. members, as follows: ARMA CORP.; CAMERON IRON WORKS, INC.; FORD INSTRUMENT CO., INC.; GENERAL MOTORS CORP., FISHER BODY DIVISION; KEUFFEL & ESSER CO.; THE MIDVALE CO.; MIEHLE PRINTING PRESS AND MANUFACTURING CO.

J. EDGAR PEW, Vice-President, Sun Oil Co., Philadelphia, Pa., a member of A.S.T.M. since 1923, on September 27 celebrated his seventy-fifth birthday with his twin brother, John G. In former years he was much interested in A.S.T.M. work and he has very closely followed the activities of the American Petroleum Institute.

Two A.S.T.M. members were elected officers of the American Society for Metals at the annual meeting of the society held November 2 in Cleveland, as follows: **Vice-President:** A. L. BOEGEHOLD, Head of Metallurgy Department, Research Laboratories Division, General Motors Corp., Detroit, Mich.; and **Treasurer:** H. K. WORK, Manager of Research and Development, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

CHARLES WIRTH, III, formerly Major, Technical Division, Chemical Warfare Service, Washington, D. C., has rejoined the staff of the Petroleum Chemicals Division of E. I. du Pont de Nemours

and Co., after more than three years in the Army. He participated in the development of flamethrowers and also of gas-protective clothing and other equipment.

EARL H. PORTER, formerly Chemist, Public Service Electric and Gas Co., Newark, N. J., is now By-Products Chemical Engineer with the company.

WILLIAM P. KIMBALL, formerly Professor of Civil Engineering, Thayer School of Civil Engineering at Dartmouth College, Hanover, N. H., has been elected Dean of the Thayer School. Dean Kimball, who assumed his post on November 1, has been acting dean of the school for the past six months and before that was assistant dean under the late Frank Warren Garran.

M. VIRGINIA SINK, Supervisor of Laboratory Women, Chrysler Corp., Detroit, Mich., has been elected Secretary of the Michigan Society of Spectroscopy.

The many friends and former associates of **INGE LYSE**, formerly Research Professor of Engineering Materials, Lehigh University, and for several years on the faculty of the Norway Institute of Technology, Trondheim, Norway, will be interested to know that with the cessation of the war he is renewing his active work in the field of materials, and communications have been received by some of his American friends indicating that he got through the war period safely.

GEORGE CALINGAERT, Director of Chemical Research, Ethyl Corp., Detroit, Mich., is President-Elect of the American Chemical Society. A graduate of the University of Brussels in 1921, he has been very active in the chemical industry and has been a member of the American Chemical Society since 1924.

F. G. STEINEBACH, Editor, *The Foundry*, Cleveland, Ohio, was presented with an Award for Distinguished Service by the Gray Iron Founders' Society at its Seventeenth Annual Convention in Chicago, October 23, 24. The illuminated scroll referred to his work in the Government and the Gray Iron Foundry industry during the war time.

COLONEL MARTIN B. CHITTICK, who, during the war period, was with the Chemical Warfare Service, is now back with his former company, Pure Oil, Chicago, as Manager of Specialty and Technical Sales. On November 14, Colonel Chittick received the Army's Legion of Merit Award, the presentation having been made in the name of the Commanding General of the Sixth Corps Area, before 150 members of Earl Carr Post, 302 American Legion, of which Colonel Chittick is a past commander. His citation points out that "As Chief of the Chemical Section of the ALSOS Mission, he organized and personally directed scientific teams which operated in the European Theater of Operations for the purpose of collecting confidential data on the development of the chemical industry in Germany. The information collected and documented by Colonel Chittick was of inestimable value to invading Allied armies in locating important chemical targets,

and to Allied officials in preparing an analysis of German chemical industries."

ZAY JEFFRIES, Vice-President and General Manager, Chemical Department, General Electric Co., Pittsfield, Mass., has been chosen to receive the John Fritz Medal for 1946, for leadership in the solution of problems affecting the production, conservation, substitution, and scientific appraisal of metals and alloys.

R. C. STRATTON, who served as Lieutenant-Colonel in the Ordnance Department, has returned to civilian life and is again Supervising Chemical Engineer for The Travelers Insurance Co., Hartford, Conn.

JOHN R. TOWNSEND, President of A.S.T.M., in addition to his visits and addresses at meetings of various A.S.T.M. districts, participates in the activities of other organizations. For example, he participated in a Symposium on Fatigue of Manufactured Parts held during the annual meeting of the Society for Experimental Stress Analysis, November 27, and on November 28 he spoke at the annual meeting of the American Die Casting Institute in Chicago. During his many weeks sojourn and travels in Europe he was particularly interested in the work on die castings and he covered some of his impressions at the meeting.

NECROLOGY

(Dates of death are given where available)

FRED C. LANG, Engineer of Tests, Inspection and Research, Minnesota Highway Department, Minneapolis, Minn. (November 19, 1945.) Representing the membership of the Minnesota Highway Department since 1926, Mr. Lang had been very active in the work of a number of A.S.T.M. technical committees, notably Committee C-9 on Concrete and Concrete Aggregates, D-4 on Road and Paving Materials, and D-18 on Soils for Engineering Purposes. He served on numerous subcommittees and sections and was chairman of a number of these. He served a term (1936-1938) as chairman of Committee D-4. An outstanding authority in his field, Mr. Lang contributed greatly to a better knowledge of highway materials and construction and his constant support of work in A.S.T.M. was indicative of his interest in advancing the Society's work.

EUGENE C. BINGHAM, Professor of Chemistry, Lafayette College, Easton, Pa. Member since 1917. (November 6, 1945.) A member of Committee D-20 on Plastics, Professor Bingham was also particularly interested in the work of Committee E-1 relating to the consistency, plasticity, and related properties of materials, serving as chairman of this subcommittee. An authority in the field of rheology, he had prepared a number of papers on this subject.

R. C. HARRIS, Commissioner of Works, Department of Works, City of Toronto, Toronto, Ontario, Canada. (September 2, 1945.)

H. S. Rawdon Retires

AFTER a period of service at the National Bureau of Standards extending from 1912, H. S. Rawdon, Chief, Division of Metallurgy at the Bureau, has retired. An outstanding authority in the metallurgical field and widely known in A.S.T.M., he has been extremely active in the work of the Society. His affiliation dates from 1917. He was a member of a number of the technical committees in the ferrous and non-ferrous metals fields and is serving as chairman of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. Dr. Rawdon has had notable periods of service on Committees A-2 on Wrought Iron, A-5 on Corrosion of Iron and Steel, E-4 on Metallography, and the Research Committee on Fatigue of Metals. He was chairman of the former Joint Committee on Investigation of Phosphorus and Sulfur in Steel, directing important work which resulted in valuable data. Also he has served as chairman of the Joint Committee on Definitions of Terms Relating to Heat Treatment. He is currently serving as a member of the Administrative Committee on Papers and Publications. In fact, his services to A.S.T.M. over the years in connection with the review of technical papers have been one of his very notable and most helpful activities.

Mention should be made of his contributions to A.S.T.M. *Proceedings* which are represented by several very extensive technical papers and much discussion. Many of his papers have dealt with problems of corrosion. In view of the new publication, Symposium on Stress-Corrosion Cracking of Metals, it is of interest to note one of his early papers in 1918 covering season and corrosion cracking and the use of mercury solutions.

Dr. Rawdon plans to continue some of his A.S.T.M. committee work. His residence is R.F.D. No. 3, Bethesda, Md.

White, Gray and Black Reflectance Standards

THE National Bureau of Standards is now prepared to issue sets of white, gray and black reflectance standards. Each set contains ten calibrated porcelain-enameled panels which diffusely

reflect approximately 80, 70, 60, 40, 20, 15, 8, 4, 0.8, and 0.5 per cent, respectively, of the light that strikes them. They are 4 by 4 in. in size and have folded edges to minimize warpage resulting from enameling.

These standards are intended primarily for use with reflectometers used to measure paints, papers, textiles, ceramic products, and other opaque materials for reflectance and approximate color by the photoelectric tristimulus method. As was pointed out in NBS Circular C429 (July, 1942) on photoelectric tristimulus colorimetry, accurate chromaticity measurements are possible only when samples and standard are spectrally similar. For this reason, accurate measurements of the colors of only near-white, near-gray, and near-black materials are possible with the new standards. They are intended primarily for use with the multipurpose reflectometer developed at the National Bureau of Standards (*Journal of Research*, Nat. Bureau Standards, Vol. 25, November, 1940, p. 581, RP 1345), and with other reflectometers used to measure 45 deg. 0 deg. directional reflectance.

Each set is calibrated with the blue, amber, and green filters described in NBS Circular C429, and is packed in a permanent, hinged-top, wooden box. The fee to nongovernment agencies is \$50 a set.

Catalogs and Literature Received

GAMMA INSTRUMENT CO., INC., 95 Madison Ave., New York 16, N. Y. A four-page folder entitled "G & D pH Automat" covers pH measurements, pH titrations, oxidation-reduction titrations, EMF measurements. Illustrated.

FAICHNEY INSTRUMENT CORP., Watertown, N. Y. Catalog No. 44 entitled "Faichney Etched Stem Thermometers—Laboratory—Chemical," 52 pages. Lists and describes laboratory grade thermometers for general testing, engineering, industrial and laboratory work and student grade thermometers. A.S.T.M. thermometers are listed and described in the catalog. Other special test thermometers are covered. Alphabetical and Numerical Index included. Profusely illustrated.

THE BROWN INSTRUMENT CO., Division of Minneapolis-Honeywell Regulator Co., Wayne and Roberts Aves., Philadelphia 44, Pa. "Instrumentation"—October and November issue, 1945—published quarterly by the company, 30 pages, covers indicating, recording, controlling, tem-

perature, pressure, flow liquid level, humidity instrumentation. A section on Instrument Technology is included and also one on Instrument Applications and Instrument Maintenance. Illustrated.

Calendar of Society Meetings

(Arranged in Chronological Order)

- SOCIETY OF PLASTICS ENGINEERS—Annual Meeting, January 7-9, 1946, Detroit, Mich.
- SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting, January 7-11, Detroit, Mich.
- AMERICAN ROAD BUILDERS ASSN.—43rd Annual Meeting, Jan. 14-18, Stevens Hotel, Chicago, Ill.
- NATIONAL SAND AND GRAVEL ASSOCIATION—Annual Convention, January 22-24, Netherland Plaza, Cincinnati, Ohio.
- NATIONAL READY MIXED CONCRETE ASSOCIATION—Annual Convention, January 23-25, Netherland Plaza, Cincinnati, Ohio.
- HIGHWAY RESEARCH BOARD—National Research Council—25th Annual Meeting, January 25-28, Oklahoma City, Okla.
- NATIONAL CRUSHED STONE ASSOCIATION—Annual Convention, January 28-30, Netherland Plaza, Cincinnati, Ohio.
- AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS—Annual Convention, January 29-February 1, Edgewater Beach Hotel, Chicago, Ill.
- AMERICAN WELDING SOCIETY—National Meeting, February 4-7, Hotel Cleveland, Cleveland, Ohio.
- IRON AND STEEL, AND INSTITUTE OF METALS DIVISIONS, American Institute of Mining and Metallurgical Engineers—National Meeting, February 4-8, Statler Hotel, Cleveland, Ohio.
- American Society for Testing Materials—Spring Meeting and Committee Week, February 25-March 1, Hotel William Penn, Pittsburgh, Pa.; Annual Meeting and Exhibit of Testing Apparatus and Related Equipment, June 24-28, Buffalo, N. Y.
- TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY—National Meeting, February 25-28, New York, N. Y.
- AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS—Annual Meeting, February 25-28, Chicago, Ill.
- AMERICAN RAILWAY ENGINEERING ASSOCIATION—March 12-14, Palmer House, Chicago, Ill.
- AMERICAN CHEMICAL SOCIETY—109th Meeting, April 8-12, Atlantic City, N. J.
- SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION—53rd Annual Meeting, June 20-23, Jefferson Hotel, St. Louis, Mo.
- NATIONAL INSTITUTE OF GOVERNMENTAL PURCHASING—Annual Conference and Products Exhibit, August 19-21, Hotel Stevens, Chicago, Ill.

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